Can Astronauts Cope on Long Missions?

AIR&SPACE
Smithsonian

The Worst Fighter of World War II?

BISONUS VULGARIS

The Invisible Menace of Mountain Winds

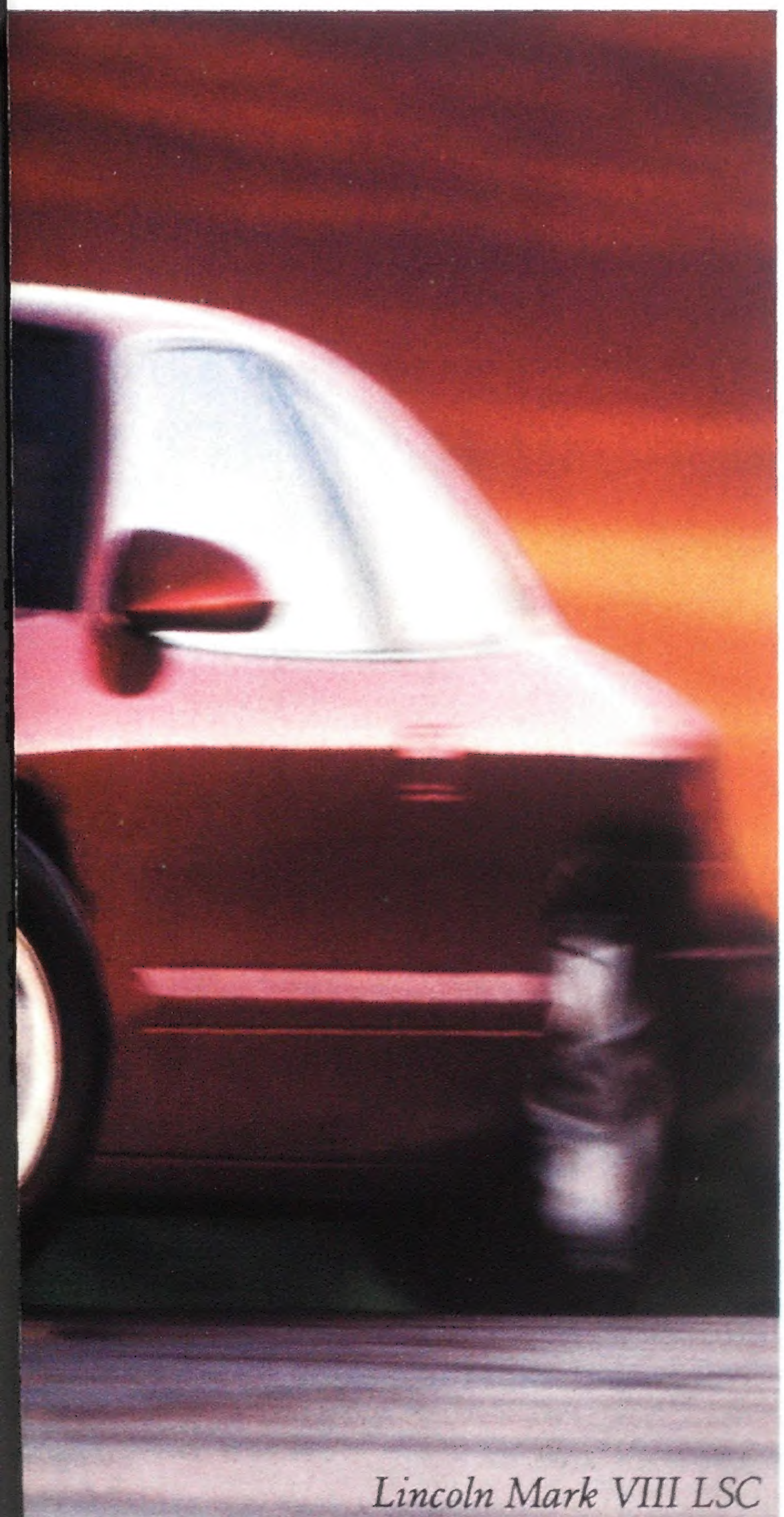
"Roger, Fido, You're Cleared for Takeoff"

PAGE 32

JULY 1996 • $3.95 U.S. / $4.50 Canada

Now Available In Ex

ra-Strength Formula.



Lincoln Mark VIII LSC

Introducing The 290-Horsepower Lincoln Mark VIII LSC.

Because some people just can't seem to get enough of a good thing, we found a way to give them even more. By creating the most responsive, most indulgent Lincoln Mark VIII ever in an exciting new luxury sport coupe edition. A coupe that anyone who puts a premium on style and performance would welcome.

It has an even more energetic 290-horsepower V-8 engine for quicker acceleration. Monochromatic accents for added flair. A taut sport suspension for better handling. Euro perforated leather seats. And new longer-lasting high-intensity Luminarc™ headlamps—a first among domestic automakers. These bright lights give off a distinct blue-white light at low beam for greater safety due to increased visibility.

Moreover, all this intelligent technology works together beautifully under the InTech™ System. A computer-managed network that constantly checks and re-checks powertrain, suspension and chassis functions. And, like all Lincolns, the engine in this new luxury sport coupe is designed to go 100,000 miles between scheduled tune-ups. Which, in itself, is quite a coup.

To learn more about this remarkable automobile, call 1 800 446-8888, or for information via the Internet, enter http://www.Lincolnvehicles.com.

LINCOLN

What A Luxury Car Should Be

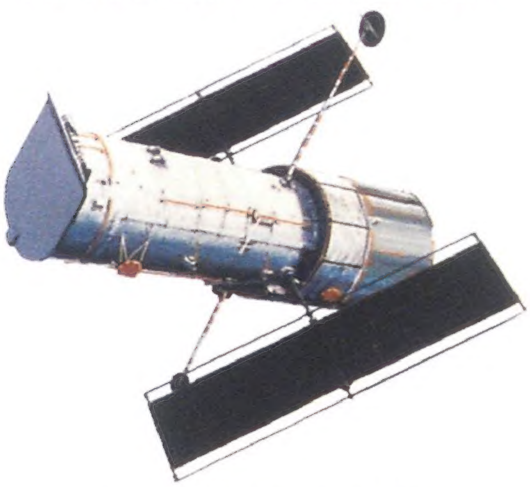
June/July 1996
Volume 11, Number 2

AIR&SPACE
Smithsonian

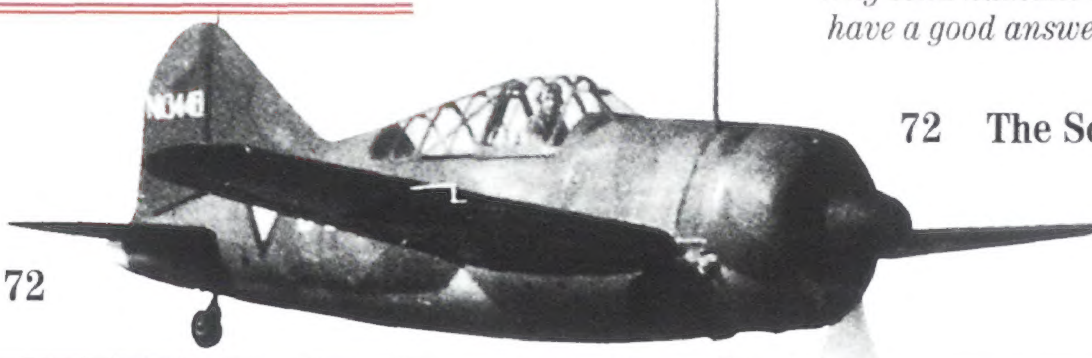
CONTENTS

36

THE VIEW FROM THE HUBBLE: PART I



62



72

Cover: Specimen of a loser? A NASM photo provides a bird's-eye view of one of the Navy's 11 F2A-1 Brewster Buffalo fighters.

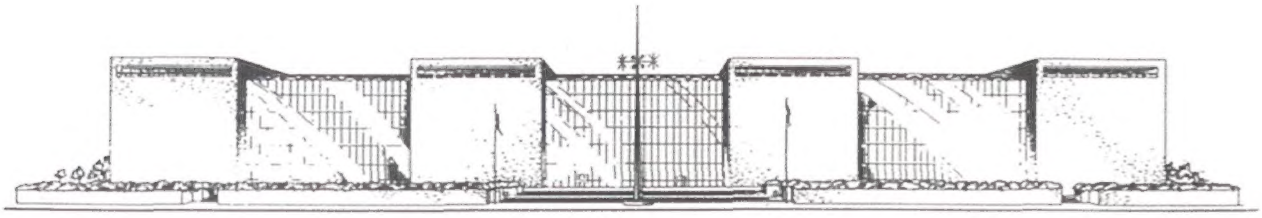
Departments

AIR & SPACE/Smithsonian (ISSN 0886-2257) is published bimonthly by the Smithsonian Institution, 900 Jefferson Drive, Washington, DC 20560. Editorial offices are at 370 L'Enfant Promenade SW, 10th Floor, Washington, DC 20024. Advertising and circulation offices are at 420 Lexington Ave., New York, NY 10170. SUBSCRIPTION PRICES: United States and possessions: $20 a year payable in U.S. funds. Canada and all other countries add $6.00 (U.S. funds) for each year. Eighty-five percent of dues is designated for magazine subscription. Current issue price is $3.95 (U.S. funds). Back issue price is $5.00 (U.S. funds). MAILING LISTS: From time to time we make our subscriber list available to companies that sell goods and services by mail that we believe would interest our readers. If you would rather not receive such mailings, please send your current mailing label or exact copy to: *AIR & SPACE/Smithsonian*, Mail Preference Service, PO Box 420113, Palm Coast, FL 32142-0113. SUBSCRIPTION SERVICE: Should you wish to change your address or order new subscriptions, you can do so by writing *AIR & SPACE/Smithsonian*, PO Box 420113, Palm Coast, FL 32142-0113, or by calling 1-800-766-2149. Postmaster: Please send change of address to *AIR & SPACE/Smithsonian*, PO Box 420111, Palm Coast, FL 32142-0111.

PRINTED IN THE USA


USA
36 USC 380
Official Sponsor of the 1996 U.S. Olympic Team. Official Sponsor of the 1996 Olympic Games. Prices shown are Manufacturer's Suggested Retail Prices for 1996 models, which exclude licensing fees, federal, state, or local taxes, freight and dealer preparation charges. Actual prices will depend on dealer. ©1996 BMW of North America, Inc. The BMW logo and trademark are registered.

VIEWPORT



The Museum's Draw

In July the National Air and Space Museum will celebrate its 20th birthday, and, as always, the public is invited. Not that anyone has ever needed an invitation. The Museum has been the number-one required stop for most Washington visitors since it opened its doors in 1976. Back then, nobody anticipated how popular it would be, and when the crowds swelled and never receded, it surprised everyone. But it really shouldn't have.

If you ask visitors why they like the Museum, they have a hard time putting their feelings into words. But as people encounter the actual airplane that Charles Lindbergh piloted from New York to Paris or the rocket-powered research aircraft that Chuck Yeager flew through the sound barrier, their upturned faces have a kind of glow.

The historic aircraft and spacecraft in the Museum are the magnets that draw the millions, and the magnetism derives from the nature of the machines themselves. When people gaze at the *Spirit of St. Louis* and *Glamorous Glennis*, the magnitude of the accomplishments can't help but reinforce a sense of hope. Humanity can accomplish great things, and here's the evidence. Because parents sense that there's something about the collection that can inspire their kids to achieve, you find a lot of families visiting, with mothers and fathers patiently explaining how jet engines work and how airplanes fly. The industry we now call aerospace is young, and the Museum's artifacts make many visitors recall moments when their own lives were touched. They look up and they see more than an airplane; they see a memory.

And visitors can get pleasure simply from the artifacts' sculptural qualities. Spare and sleek, the airplanes and rockets embody the notion that form follows function. The Museum comes as close as a technology-celebrating institution can to being an art collection.

I think visitors intuitively understand that the machines and implements of aerospace are different from those of other technologies, that they exist—forgive me—on a higher plane. Flight is uncompromising and does not allow for incompetency, and the cheat and the charlatan don't last long in a business where the laws of physics rule. That's why the people drawn to the field truly like the honesty of the challenge. It's a performance arena, and if your airplane is no good, you can't hide it.

One of the best-kept secrets about the Museum is, at least for me, the strongest reason for its popularity. As aviation and spaceflight have matured from their sporty pioneering days to heavy industry, the fun part has tended to get lost. Not here, though. The Museum building itself plays a role: The architecture is light, airy, open, and your ceiling is the sky. The Museum has always been one of the most festive on the Mall, and even the presence of a number of military machines in the great halls can't alter the mood. We know they painted Yeager's airplane a bright color so it could be easily seen through tracking telescopes, but hey, it's orange! And on the mezzanine level above the treasures of Milestones of Flight you'll find the whimsical, flapdoodle human-powered airplane built by Paul MacCready out of freezer wrap.

So get ready to party. This summer the Museum will premiere a new IMAX film, *Cosmic Voyage*, along with two planetarium productions. A "You Can Fly" expo in late June will bring learn-to-fly information to tens of thousands of visitors. And in late summer, a new gallery, "How Things Fly," will answer all those kids who wonder: *What keeps airplanes up in the air?*

We wish the National Air and Space Museum many happy returns.

—*George C. Larson*

To participate in live online chats with the editor on Monday evenings at 9 p.m. EDT, you'll need access to America Online (for free software and 15 free trial hours, call 1-800-978-1818). Under "keyword," enter "Smithsonian," then click on the "Smithsonian Hall" icons.

AIR&SPACE
Smithsonian

Secretary of the Smithsonian Institution
I. Michael Heyman

Editor
George C. Larson

Managing Editor
Tom Huntington

Senior Editor
Linda Musser Shiner

Departments Editor
Patricia Trenner

Senior Associate Editor
Perry Turner

Associate Editors
Karen Jensen
Diane Tedeschi

Photography/Illustration
Caroline Sheen

Art Director
Phil Jordan
Gretchen Lessing

Cover Design
Lasko Design

Publisher
Ronald C. Walker

Administration
Carey O. Randall, Associate Publisher

Advertising
Louis C. Kolenda, Director

Circulation
Liberta Abbondante, Director
Caroline Topak, Marketing Director
Elizabeth Hopkins, Planning Director
Andrea Sole, Fulfillment Director

Production
Sarah D. Kingsley, Manager
Sue Nixson

Business
Shelia Perry Brannum, Manager

Founder
Walter J. Boyne

Publisher Emeritus
Joseph J. Bonsignore

Telephone
Editorial: (202) 287-3733
Advertising: (212) 916-1345

An Unbalanced Portrayal

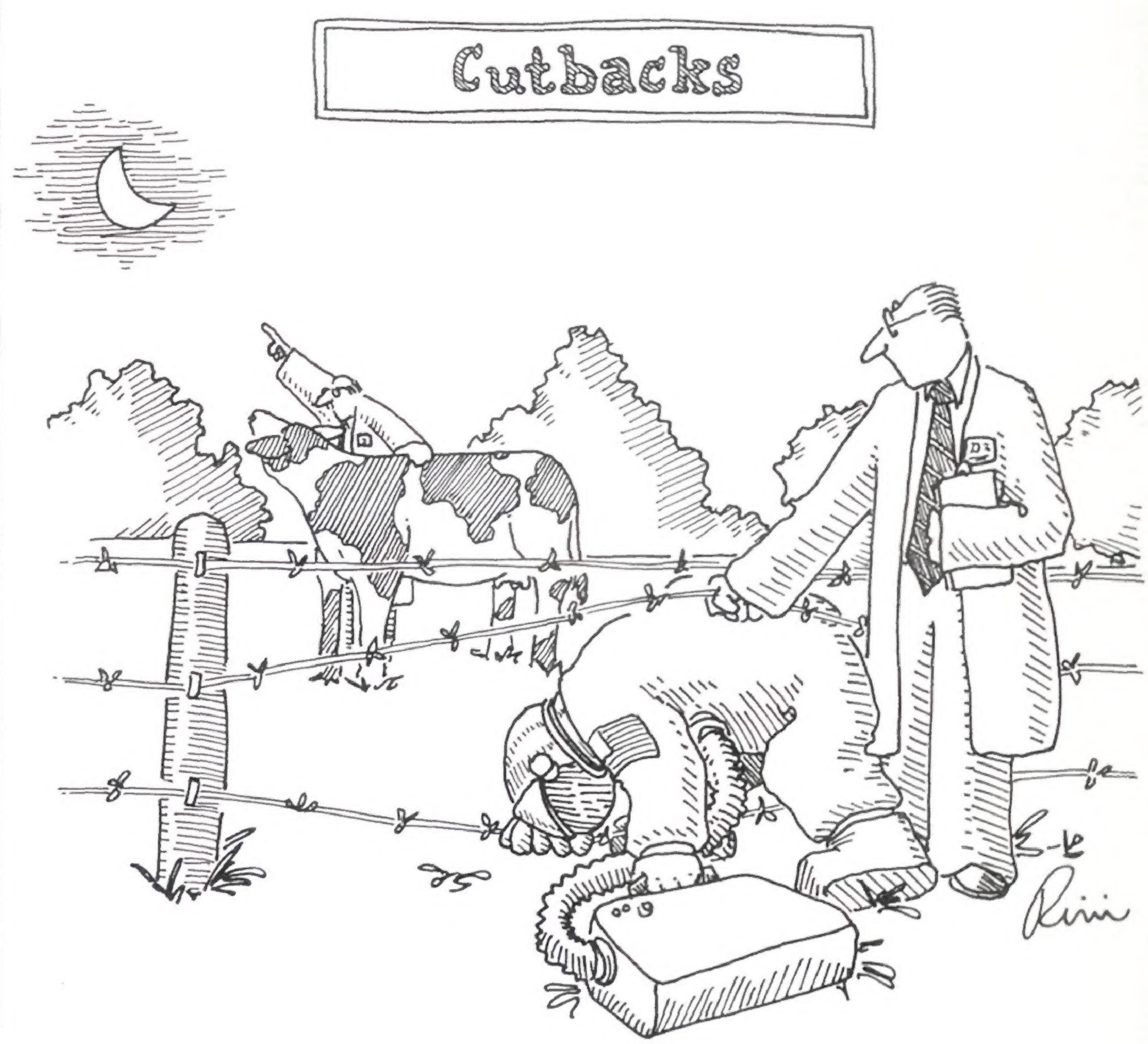
The photograph on page 53 of "The Rise and Fall of the East German Aircraft Industry" (Feb./Mar. 1996) suggests why the Model 152 had trouble flying: The starboard wing appears to be significantly shorter than the port wing. Additionally, the wing fences look to be much closer on the starboard wing than they are on the port wing.

Perhaps while the plans were being carried from Moscow to Germany, some nefarious sort intercepted them and sabotaged the design to eliminate competition.

—John M. Lenci
Virginia, Minnesota

Editors' reply: The photograph is *odd (and the phenomenon can also be observed in the aircraft in the background). We are unable to envision a scenario in which two different wing designs would be attached to the same aircraft. The author of the article, Fred Stahl, believes the differences are just an optical illusion, resulting from the angle at which the photo was taken and the fact that the craft's wings are not only swept back but have a negative dihedral—a downward slope from fuselage to wingtip. Then again, maybe the differences in the wings' appearance were produced by something, either deliberate or inadvertent, that happened while the photograph was being printed.*

We welcome other theories.



Air and Space Futures, Revisited

I'm currently working on the "next generation" launch system known as Single Stage to Orbit, also sometimes referred to as the Reusable Launch Vehicle. Don't you think it odd that none of the contributors to the "Air and Space Futures" section of your 10th anniversary issue (Apr./May 1996) made even a casual reference to this planned replacement of the shuttle? And that includes the CEO of the aerospace company I work for!

—L.P. Scott
via e-mail

In the "Get Smart" section of "Air and Space Futures," you focus on smart wings and smart engines. All these components hinge, often literally, on the nascent fields of smart fasteners and smart structures. Our company is involved in the development of both. Smart bolts are made from high-strength steel alloys whose magnetic properties change permanently in proportion to the maximum applied strain. Each bolt has a cavity through its center, and a probe inserted into the cavity can measure the changed magnetic field and hence the peak strain that the bolt has experienced. The bolts can be calibrated to respond to a strain level below that which would result in structural failure, enabling the bolt to warn of impending failure. Interrogation of the bolts can be performed during routine aircraft maintenance.

The same kind of steels can be used to formulate tiny wires that, when embedded in composite skins, stringers, and frames, give the airframe the capacity to announce the status of its structural integrity.

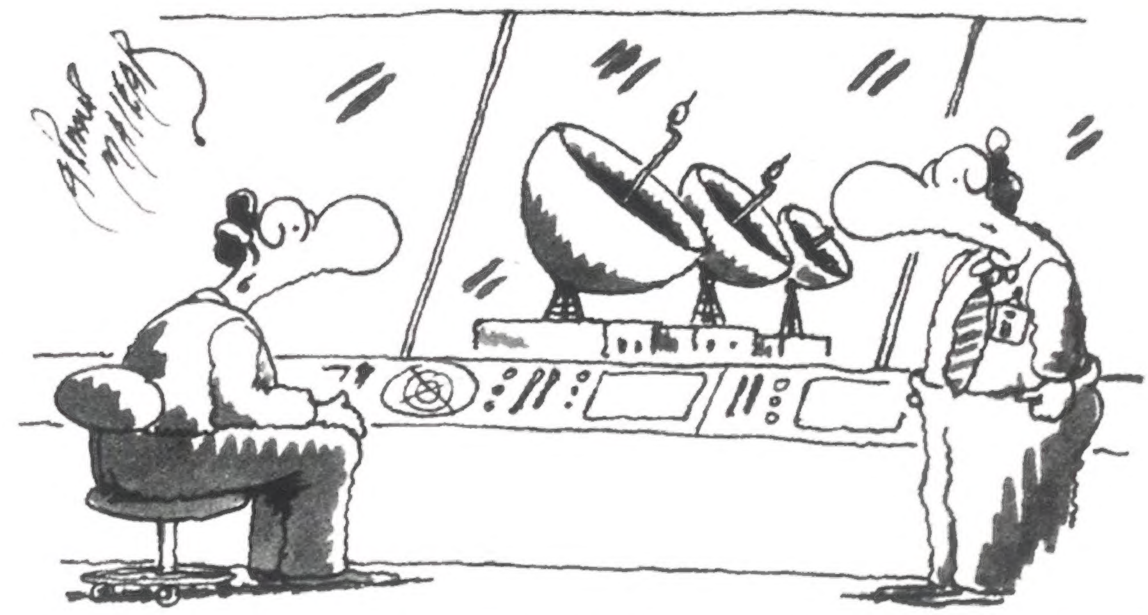
—William Law
Strain Monitor Systems
Atlanta, Georgia

Setting the Lindbergh Record Straight

In his letter in the Feb./Mar. 1996 issue, Howard Oglesby asserted that he flew with Charles Lindbergh on a mission to Balikpapan on October 14, 1944, and that on the mission, Lindbergh shot down an enemy plane. Oglesby is mistaken. Lindbergh had returned to the United States a month earlier, and on October 16 he attended the Joint Fighter Conference held at the Patuxent River Naval Air Station in Maryland.

Lindbergh engaged and shot down only one enemy aircraft: over Ceram Island in the vicinity of Amahi airstrip on July 28, 1944.

—John Underwood
Glendale, California



"We received a message from space, sir. They asked if we wanted to be in their friends and family calling circle."

Laika's Sad Fate

According to the 1995 almanac, Laika, the first animal in orbit, died from a lack of oxygen, not from her spacecraft overheating, as stated in "Match Race" (Feb./Mar. 1996).

—Shawn Heckman
Southgate, Michigan

Peter Gorin, coauthor of "Match Race," responds: Because the life support system on Sputnik 2 was designed to work for seven days, most writers assume that after that period, the poor dog died from a lack of oxygen. Though none of the Russian sources indicate how long Laika really lived in space, it is certain that she died prematurely. Abram Genin, a direct participant in the flight, recalled: "...we ran numerous experiments and became convinced: the excessive heat—not weightlessness or any other factor—killed the dog" (from the 1992 book Roads to Space, *my translation).*

Throb Story

In "B-36: Bomber at the Crossroads" (Apr./May 1996), Daniel Ford writes that the pusher propeller design apparently worked because the bomber had very low drag. I read an article in *Aviation Quarterly* (vol. 4, no. 4) that said in part: "Of all the problems encountered, though, perhaps the biggest was that of wing slipstream turbulence. With individual blades popping in and out of this several thousand times per minute, it was quite obvious that fatigue problems would be severe." The article continues: "Following its entry into the Air Force/Strategic Air Command inventory, the B-36 was beset with a series of problems related to the propeller and propeller shaft fatigue." The problems were so severe that a tractor propeller program was started. This was supposed to be the B-36C, but the program was canceled.

This phenomenon of propeller blades repeatedly entering and leaving slipstream turbulence may have produced the B-36's unique throbbing sound. My father recalls B-36s flying over his hometown—Binghamton, New York—late at night, and though he could never see them, he could always hear them.

—Peter C. Maher
Chicago, Illinois

We Demand a Recount

Dee Mosteller did an exceptional job of research for "The Big Ten" (Feb./Mar. 1996), but I must oppose the final rating of the Piper Cub, which is based on her statement: "Production of Piper Cubs started in 1937, when the first model J-3 rolled out of the Lock Haven, Pennsylvania factory...."

Most people are familiar with the Cub only as the "Piper Cub," so they think production started the year the Piper name was first used. In fact, the Cub was originally produced by the Taylor Aircraft Company, which began turning out the E-2 Cub in 1931. The E-2 remained in continuous production through 1936. In the fall of 1935, company engineer Walt Jamouneau converted an E-2 into the J-2 configuration by gracefully rounding the wingtips and rudder and widening the landing gear tread. In March 1937 the Cub production facility in Bradford, Pennsylvania, burned to the ground. Production of the successful J-2 series was moved to Lock Haven three months later, at which time the company's name was changed to Piper Aircraft Corporation. By autumn, engineers were modifying the J-2 into the J-3, which retained the J-2's overall configuration but was more attractive, comfortable, and capable.

With a continuous production run of 52 years, the Cub is the number-one winner of the Big Ten.

—Harry P. Mutter
Board Member, Piper Aviation Museum
Media, Pennsylvania

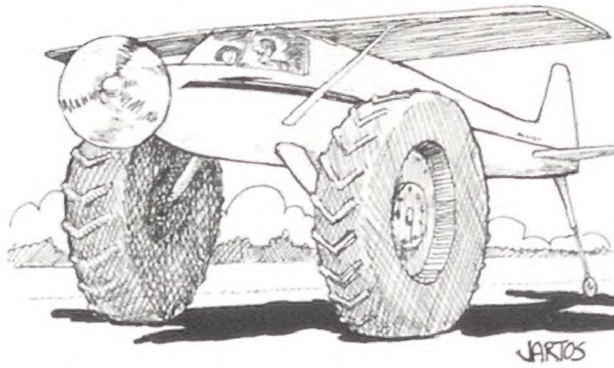
It Pays To Be Thick-Skinned

In "When Ships Have Wings" (Dec. 1995/Jan. 1996), Colonel Mike Francis, recounting that the hull of the Orlyonok was made of quarter-inch-thick ship aluminum, comments that the Russians' "view of structures and materials is still on a ship builder paradigm." I have repaired a rip in the hull of a Martin Mars, an aircraft similar in size to the ekranoplans, and I believe some hull plates were aircraft-grade aluminum near 3/16 of an inch thick. Since the Orlyonok was built to withstand collisions with waves at speeds of perhaps 200 mph, its hull design does not seem unreasonable.

—Theodore M. Long
Somerville, New Jersey

Product Placement

My God. "Advertising Space" (Dec. 1995/Jan. 1996) makes it painfully obvious that we must reawaken this country's interest in space exploration. The copy in the ad on page 67 states: "50 years ago, no one would have known what this was a picture of." Apparently, the ad's



"Whenever the insanity of modern life gets to me, I find solace in the blue skies here in my little plane with the monster tires."

creators, Citron Haligman Bedecarré, still don't. They rotated the photograph of Earth so that the South Pole appears at the equator.

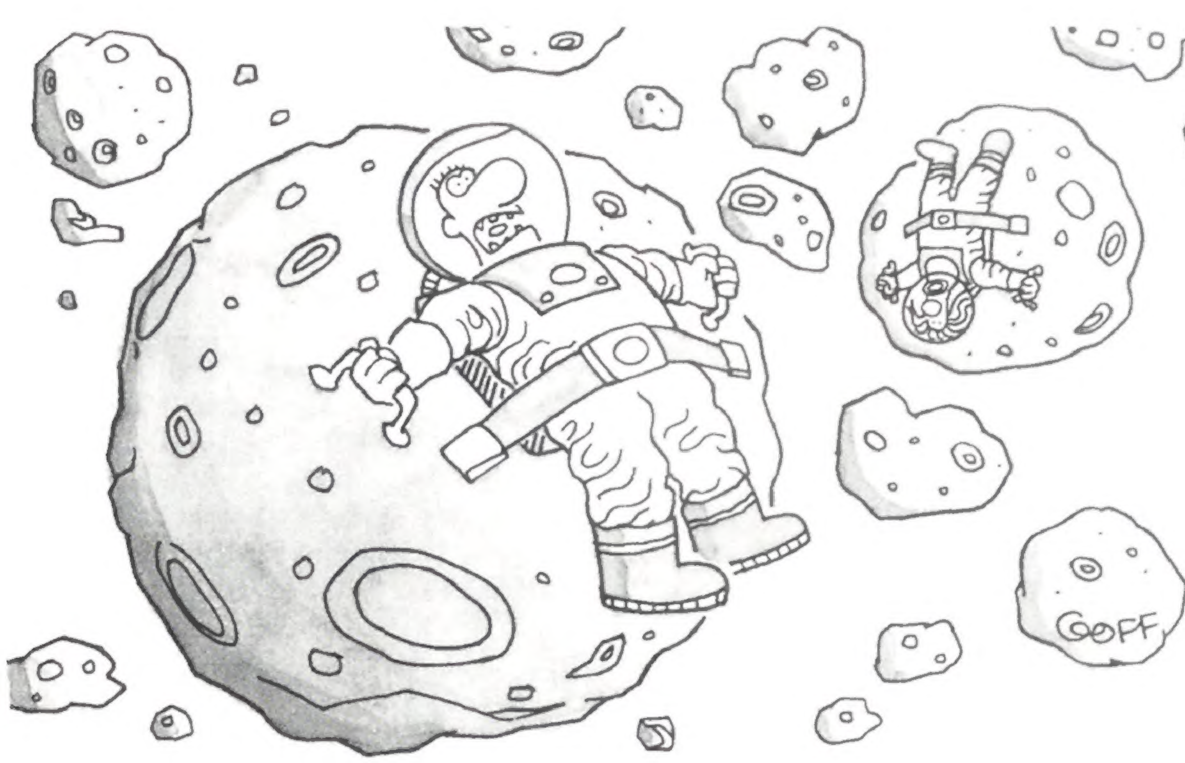
Bringing in ignorant PR shills to sell NASA as if it were beer or deodorant is the wrong approach. We're numbed enough by public relations. If we're going to revitalize America's space program, we've got to find a way to free the truly imaginative minds at NASA from the tangles of bureaucracy and rekindle what I felt as an eight-year-old boy watching Armstrong and Aldrin hop around on the moon: magic.

—Mike Leitz
Cincinnati, Ohio

Ouch! Hey! Slow Down!

I do believe that the MAGLEV concept is the next step in the refinement of high-speed transit. However, the diagram in "An Express of the (Near) Future" (Dec. 1995/Jan. 1996) notes that the train would travel over 7,300 feet a second and that the tube would have a linear variation of one foot per 2,000 feet. Therefore, unless the MAGLEV remained perfectly parallel to the tube at all times, the train could hit the tube 3.6 times a second. It's doubtful that passengers would be able to survive that abuse even if attire was furnished by the NFL.

—David Long
Minneapolis, Minnesota



THRILL SEEKERS IN 2254

No Way to Impress an Investor

"Auto Pilots" (Dec. 1995/Jan. 1996) made no mention of the aerocar developed by Joe Gwinn in Buffalo, New York, in the late 1930s or early '40s. It held two people and its wings twisted and folded back along the fuselage. It had a tricycle gear and could be driven like a car. I was acquainted with Gwinn and was checked out in the aerocar.

Gwinn needed financial assistance for his invention. He found a millionaire, and Frank Hawks flew Gwinn to the man's mansion, which had a big field next to it. They all had drinks on the patio facing the field.

Hawks was supposed to demonstrate the airplane for the prospective investor. He got up from the table and took off right there, instead of taxiing to the end of the field. Because he did not have enough clearance, he hit some telephone wires and was killed. Gwinn's aerocar never got the financial support it needed.

—Robert W. Fausel
Towson, Maryland

Corrections

April/May 1996 "Winged Warriors" (Collections): O-47s did fly observation missions during World War II, primarily on both coasts of the United States, on approaches to Panama, and in the Antilles.

"Crossing the Atlantic": The *Mercury* had four engines, not two.

Address letters to: Letters, Air & Space/Smithsonian, *901 D St. SW, 10th Floor, Washington, DC 20024. Please type or print clearly, and include your daytime phone number.*

Letters will be edited for publication. Air & Space *is not responsible for the return of unsolicited photographs or other materials.*

e-mail *You must include your full name, mailing address, and daytime phone number. America Online:* airspacedt, *Compuserve:* 75361,3425, *Internet:* airspacedt@aol.com.

impotence

Why suffer needlessly when there are specialists that can help?

The facts. Almost every man can successfully overcome impotence • It is a treatable condition, regardless of age • Up to 75% of all cases are physical in nature, not psychological • There are a limited number of physicians who are experienced in the diagnosis and treatment of impotence • It is important to visit a specialist because they can offer you the widest range of treatment options.

Call 1-800-867-7012 today.

We'll send you a Free Information Kit. And because it is important that you visit a physician experienced in treating impotence, we'll also provide you with the names of specialists in your area.

Visit our web site at http://www.impotent.com

Pharmacia & Upjohn

God Is in the Decals

Frank Samora and his crew at California's McClellan Air Force Base are responsible for the largest traveling art show in the world, all done to military specs. Samora's Silk Screen Shop prints all the decals, insignia, and flags required for U.S. Air Force aircraft. "We often do subdued colors, grays and greens and browns, for camouflage," Samora says. "So they can disappear." Now he hopes that his shop won't meet the same fate.

The McClellan shop, already downsized from 13 to seven people, prints four million items annually for the Air Force, the Army, and foreign governments. Jobs range from quarter-inch decals to five-foot flags for the C-5 transport. The shop even does the occasional bumper sticker.

Most military missions are more mundane than keeping the peace. But none—certainly not those in Bosnia—could be flown without the work of the Silk Screen Shop. Its work appears on everything from the smallest spotter aircraft to Air Force One. The artwork is serious business. "Aircraft have been downed because they didn't have the [proper] markings," says Jim Cortese, McClellan's chief of information management.

While McClellan is set to close in July of 2000, the future of the Silk Screen Shop "will be decided by the Defense Depot Maintenance Council later this year," says the base's media relations chief, Jack Hokanson. It could be closed and the work contracted out, or the shop could be moved to another base.To make a case for preserving the shop, last September Samora lobbied military heads in Washington, armed with a case full of the 2,500 decals needed to make a single KC-135 tanker airworthy. "We were so low-profile, they practically didn't know we existed," he says.

These days, Samora and his crew "just take it one day at a time." Samora may have developed his philosophical poise in Vietnam, where the Army failed to recognize his talents as an illustrator and made him an infantryman. He once created a stencil and painted a caterpillar, his unit's logo, on the side of an armored personnel carrier, but "They made me take it off," he says, "because the Army said it was a target."

—Bob McCafferty

GEOFF CHESTER

The most spectacular naked-eye comet since Comet West in 1976, Hyakutake held skywatchers spellbound late last March with its huge, bright coma and 62,000-mile tail. The comet, traveling at 90,000 mph, passed within 9.3 million miles of Earth on March 25. "It's been almost 20 years…since you could step outside, look into the sky without any aid or mind-altering substances, and say, 'Wow, that's a comet!' " said National Air and Space Museum astronomer Geoff Chester, who captured Hyakutake in the northwestern Virginia sky. Stay tuned for Hale-Bopp, which is due next spring and could be a real blazer.

CAROLINE SHEEN (2)

The Next Picture Show

Something of a race is developing to bring unlimited air racing from the Reno National Championship Air Races ("The Last Piston Show," April/May 1992) to a theater near you.

Producer Roger Birnbaum, head of Caravan Pictures, an independent motion picture company based at Walt Disney Studios, announced last April that his company will produce *Air Reno*, an action yarn that traces the story of Wes Skyles, a pilot exiled from racing who returns to teach aerobatic pilot Jo Anne Paxton to be a world-class flier. The press release describes it as "set in a unique milieu of flying daredevils."

No names have been attached to the Caravan project, although Kevin Costner and John Travolta have been mentioned as under consideration for the lead, and Sandra Bullock is rumored to be set to play the heroine.

Co-starring is *Miss America*, one of the most enduring of the Unlimited-class racers. The P-51 Mustang is involved in the film's finale, a race through the Grand Canyon. Aviation services will be provided by the Champion Air Group, headed by Alan Preston, who was crowned 1994 Unlimited champion in *Miss America*. (See the legendary racer at the *Air & Space* booth at airshows at Oklahoma City, June 14-16; San Diego, August 16-18; Houston, September 21-22; and New Orleans, November 2-3.)

The entertainment trade paper *Daily Variety* reports that a second feature, *Air Speed*, is being developed by the Fox 2000 production company. It concerns a cropduster who ends up racing at Reno. At the moment, the Hollywood/Caravan Pictures project has the early lead, having acquired exclusive rights to film on location at the 1996 Reno event, which will take place in September.

Breaking details will be posted on the *Air & Space* Website's Reno Air Races pages (http://www.airspacemag.com/Reno/Home.html).

—Larry Lowe

UPDATE

Former Eagle Killed in Freak Mishap

Airshow pilot Charlie Hillard, a member of the Eagles flight team ("The Eagles Have Landed," June/July 1995), was killed last April 16 when his Hawker Sea Fury flipped over during a landing rollout at the Lakeland, Florida Sun 'n' Fun fly-in. "People keep asking me how this could possibly happen after we flew together for 25 years without scratching an airplane," says former teammate Tom Poberezny. "Regardless of what is found to have been the specific cause, there's just one reason that matters: There is a design in our lives, and it was Charlie's time."

Cheap Thrills

"Herring boxes without topses sandals were for Clementine," goes the folk song. Two spacecraft of the same name are just about as inexpensively outfitted. While typical interplanetary missions cost billions, Clementine 1 observed the moon close-up for $75 million in 1994. Now Clementine 2, slated to blast craters in three near-Earth asteroids beginning in 1998, promises to again show the space community that a mission can cost as little as $120 million.

"They all hate us," jokes Stewart Nozette, deputy program manager for Clem 1 and now manager for Clem 2. Actually, Nozette has been inundated with friendly requests from scientists who want their experiments on board.

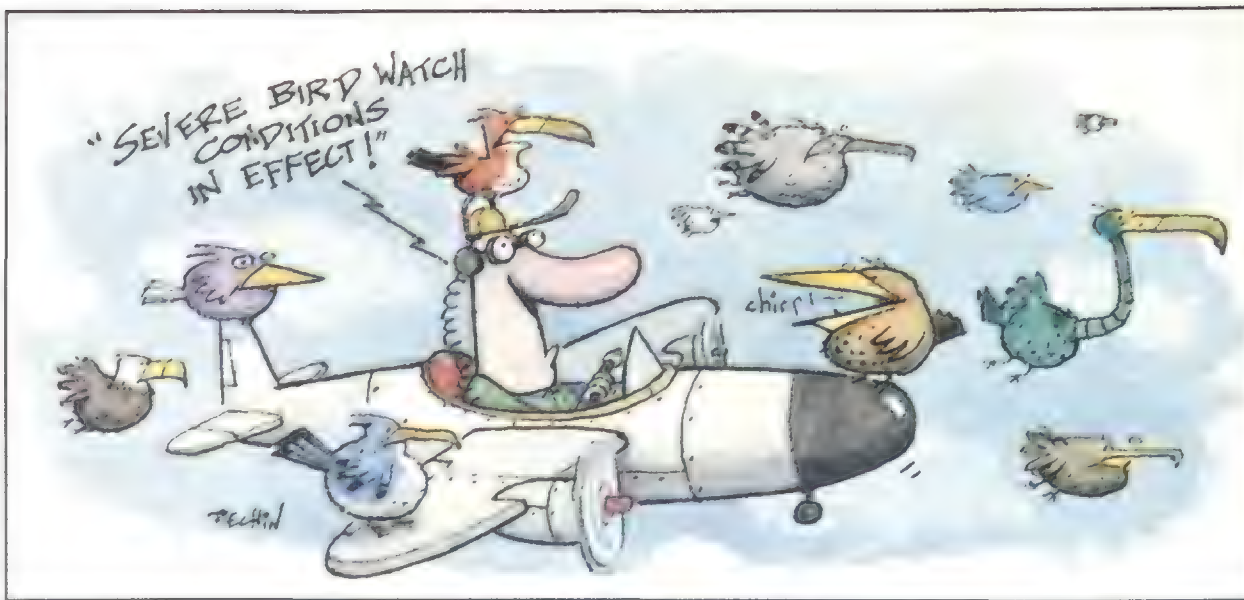
Following a summer 1998 launch from California's Vandenberg Air Force Base on a Titan IIG booster, Clem 2 will cruise along the orbital path that Earth takes around the sun. On the way, the mother craft will launch three daughter spacecraft that will collide with three different Earth-crossing asteroids. Weighing about 45 pounds and measuring perhaps three feet in length, the "microspacecraft" will transmit photographs as they speed toward their targets: rocky asteroids with diameters between 1,600 and 3,200 feet. At a closing velocity of more than 22,000 mph, each probe will vaporize on impact, creating a flash visible from the mother craft and forming a crater in the target asteroid.

By studying the debris, the shape and size of the crater the probes leave behind, and possibly the light from the flash, Clementine 2's controllers hope to learn more about the asteroids' composition, according to Thomas Karr, head of the Space Group at Lawrence Livermore National Laboratory, a partner on the Air Force project, along with the Naval Research Laboratory.

Earth-crossing asteroids pose a potentially devastating, although remotely probable, threat to Earth. Others have proposed mining the Earth-crossers, but Karr says the real point of the mission is technology demonstration: proving NASA's "faster, better, cheaper" concept. "The real trick is that we use a lot of little companies," says Nozette. "The company that built our data recorder was really a father-son garage company that came in with a very low bid."

Nozette says he feels a kinship with some of the older Apollo engineers who accepted the possibility of failure as part of flight testing. An aversion to risk and the demand for flight-qualified hardware require the use of technology that's "mature"—namely older and more expensive. "In the current NASA programs, they are all committee-ized, so they can't really fail at anything but then they can't get anything new," says Nozette. "So then they're caught up in this cost structure and this way of doing it that's prohibitively expensive." Clementine 2 may fail, but then so did some of the 49ers who rushed west in search of gold, singing "My Darling Clementine."

—Randall Black



KEVIN RECHIN

A press release from the Air Force's Air Mobility Command announces project BASH, Bird Aircraft Strike Hazard, designed to reduce bird strike accidents. "We have to look at bird watch conditions the same way we do severe weather," says Major Chris Birge, chief of aircrew training integration. AMC laid down "new rules of engagement" to observe when birds are mustering. Hence, a sort of Beaufort Scale for bird numbers:

- *Moderate bird watch condition—five to 15 large birds (waterfowl, raptors, or gulls) or 15 to 30 small birds (terns or swallows). Local training flights cease.*
- *Severe bird watch condition—more than 15 large birds or 30 small birds. No takeoffs or landings without approval from the operations group commander.*

Third Time's the Charm

The first successful launch of the troublesome Pegasus XL rocket spanned only about 11 minutes, but for the Orbital Sciences Corporation crew who built the vehicle, it was the longest 11 minutes of their careers. After two back-to-back failures of the Pegasus XL, OSC struck pay dirt with the third try, when its new booster, launched from a modified L-1011 airliner at 40,000 feet, put a small Air Force experimental satellite into a polar orbit last March.

Project team members went ballistic at mission control at Vandenberg Air Force Base in California as flight data showed that the three-stage rocket was performing in textbook fashion and the military satellite was in a near-perfect orbit. Their cheers were a mixture of triumph and relief. "We've got about 125 people on the team and many of them have been here before [without success], so there was a lot of pent-up emotion," said OSC vice president J.R. Thompson.

The company had previously tried to launch its Pegasus XL—a beefier version of its original Pegasus rocket—in June 1994 and June 1995, but in both cases, the rockets and their payloads were destroyed. The first failure was due to a design error that created aerodynamic instability; the second was caused by an assembly error.

Following the failures, OSC, working with the Air Force, NASA, and other industry experts, spent painstaking months and about $10 million in a nose-to-tail review of the effort, Thompson said. If all continues to go well, OSC officials plan to launch five more Pegasus XLs this year, four for NASA and one for Spain. The launches will be made every six or seven weeks—an aggressive schedule that will clear up a backlog of payloads that have been waiting as long as two years to fly.

"This was a big, big, big first step," Thompson acknowledged. "There was nothing more crucial than this [launch], but we're in it for the long haul and we're already looking ahead."

For the moment, however, the OSC team was happy to dwell on its accomplishment. The celebration continued later that night at a pizza and beer party where team members savored victory cigars and replayed a video of the launch over and over.

—*William H. Boyer*

UPDATE

SERGEY SKRINNIKOV/MIR AGENCY

The Red Army choir boomed out "God Bless America" and the NASA representative thanked his Russian hosts for "sharing our joy." The rollout of the made-over Tupolev 144 supersonic transport at the Zhukovsky Flight Test Center last March was a welcome display of political warmth ("Encore for an SST," Oct./Nov. 1995). But the Russian and American sides held different perceptions of cooperation's limits. Russian Transport Minister Vadim Zamotin told the crowd, "We have taken the decision to build the second generation of supersonic transport together." Louis Williams, director of NASA's alliance development office, privately set the modest goal of "verifying in flight how well we can predict from small models." Tupolev's chief designer, Alexander Poukhov, showed a firmer grasp of reality than his boss. "We understand that only American manufacturers have the money to build a second generation," he said. "But our experience can be a great help to them."

—*Craig Mellow*

The Great Paper Salvage

"Gone But Not Forgotten," read the blue bumper sticker with the Pan American Airways logo. On another car, a license plate frame bore the same slogan. And on a door, a sign with the phrase led the way to a Montville, New Jersey warehouse.

Inside, Edward S. Trippe, president of the Pan Am Historical Foundation and son of Pan Am founder Juan T. Trippe, addressed a group of former Pan Am employees. "This mammoth task could not be done without people like you," he told us, referring to the culling of mountains of Pan Am papers.

The foundation had spent $135,000 for boxes of historical material at Pan Am's bankruptcy auction in September 1992, with money scraped together by friends, former Pan Am directors, and corporations like Boeing. A clause in the sales contract gave the foundation a bonus—85,000 boxes of Pan Am's routine archives. These were initially whittled down to 5,000. Now we were to go through those, finding material to be sent to the University of Miami's Otto Reichter Library, Archives and Special Collections Department, where Pan Am's historical and public relations archives have found a home. According to department head Bill


YVONNE M. CONDE

GONE BUT NOT FORGOTTEN

Brown, "It is the most requested collection in the archives and special collections. Pan Am had a sense of its history."

Under his supervision, we were given the opportunity to cull the first group of boxes. Legal briefs. Verdict: toss out. Another contained patents for navigation equipment, possibly something of value. This box went into the "look into" pile to be evaluated by specialists, although to Brown, we, the former employees, are "the experts on Pan Am." I was a Pan Am flight attendant for nearly 20 years, leaving in 1989 on an early-out package.

About 100 "experts" signed up for the archival dig, hearing of the salvage effort through the Pan Am grapevine. Sitting around large tables, we decided for ourselves what to keep or toss. Delighted squeals and "Remember this?" interrupted the work frequently, as photos or interesting items were found. A team leader answered our questions. For a few hours, Pan Am was alive again.

What were we looking for? Historical items. Any material from before the 1930s or during either of the wars, and letters from former Pan Am presidents Trippe, William Seawell, Najeeb Halaby, or historical figures. Also any material from a secret World War II airport development program Pan American undertook for the U.S. War Department. Stock certificates? They have been bought by a speculator banking on their collectible value.

"We found Lindbergh letters," said a jubilant Kathleen Clair, who was Juan Trippe's personal secretary for 32 years. I discovered videos, taped speeches, letters from Oral Roberts, Dean Rusk, and Senator Barry Goldwater, and file upon file of employment requests from around the world. It seems everyone wanted to work for Pan Am. Only a lucky few of us did.

—*Yvonne M. Conde*


ROGER RENKEN/MCDONNELL DOUGLAS

McDonnell Douglas rolled out the latest X-plane last March at its St. Louis facility. Tailless as a Manx cat, the X-36 drone is designed to combine stealth, agility, and supersonic speeds by using engine thrust vectoring and a variety of control surfaces, including split ailerons that can open and close asymmetrically. The 28-percent-scale test aircraft, the first of two to be built, will begin a six-month test regime at NASA's Dryden Flight Research Center in California this summer.

Happy 20th Birthday!

Twenty years! Surely the National Air and Space Museum at 7th Street and Independence Avenue cannot be two decades old. Several years ago, at a retreat for senior NASM administrators, Mike Fetters, our "twenty-something" chief of public affairs, mentioned that he had first visited the Museum when he was 12 years old. That, I remarked, must have been in the days when we occupied quarters in the Arts and Industries Building and in the historic tin shed behind the Smithsonian Castle on the Mall. No, he said, his first visit had been to the new building, which opened its doors on July 1, 1976. Seldom have I felt so old.

A great many things have changed in 20 years. Four directors have come and gone. New galleries have replaced a good many of those with which we opened the building. Temporary exhibits have enjoyed their moment in the sun and then passed into history. We have catalogued almost 26,000 objects into the collection since 1976, including such national treasures as an SR-71 Blackbird reconnaissance aircraft and the prototype space shuttle, *Enterprise*. Beyond that, we have produced a steady stream of IMAX films, planetarium shows, publications, and educational programs. Some of the great names in aerospace history have spoken from the stage of the Langley Theater.

Through it all, one great fact of life at the "new" NASM has remained unchanged. Over 35,000 people walked

through the doors the day they opened. The one millionth visitor arrived just 25 days after the opening, the two millionth less than a month later, and the 10 millionth just one year and one week after opening day. And they have kept coming in numbers that cannot be matched by any other museum in the world. Between July 1, 1976, and December 31, 1995, a grand total of 174,312,640 people visited the National Air and Space Museum.

As anyone familiar with the Museum will tell you, however, it has not been all clear skies and smooth sailing. Though the staff members have enjoyed good times, when everyone seemed to be singing the praises of the Museum, we have also weathered some decidedly rough spots, when the priorities and direction of the organization were called into serious question. It really should not be too surprising to discover that the world's most visited museum has been close to the center of an ongoing debate over the role of such institutions in our society.

What do the next 20 years hold in store? Some things seem fairly clear. I have no doubt that visitation will remain very high. By the year 2016, NASM will probably have welcomed close to a quarter of a billion visitors. We will also have opened the Museum extension at Washington Dulles International Airport in northern Virginia, which is now taking shape on the architect's drawing board. The Dulles facility will expand the ability of our dedicated collections management staff to preserve and protect artifacts too large to be exhibited downtown. Moreover, the planning process will provide the entire NASM staff with rich opportunities to create an exciting new museum. When complete, the Dulles facility will provide 21st century visitors with a better understanding of how flight has shaped their world and their lives.

Looking toward the future is a healthy exercise. On the occasion of our 20th birthday, however, I hope that a NASM veteran of more than two decades will be permitted just a moment to celebrate our past, and suggest that we tip our collective hats to all of those who helped fulfill the dream of founding curator Paul Garber, and to those who will continue to pursue that dream into the future.

—Tom Crouch is chairman of the aeronautics department.

In 1976 the National Air and Space Museum's first director, former Apollo astronaut Michael Collins, asked the CIA to donate an artifact that he figured would be a big hit with visitors: the world's first spy satellite, code-named Corona. Friends of the Museum will be pleased to learn that the Corona satellite will finally arrive next February. Concern with secrecy, not heavy traffic, is what delayed the satellite in its long journey from CIA headquarters in Langley, Virginia, to the Museum. But Corona might never have made it to NASM at all were it not for an event that hardly seemed conceivable in 1976: the end of the cold war.

NASM was the first museum to have an exhibit that offered tangible proof of the cold war's end—one that continues to greet visitors today as they walk in the front door. The United States and the Soviet Union agreed in 1987 to eliminate a whole class of medium-range missiles, the first operational nuclear weapons ever banned by treaty. Three years later, examples of the two most potent missiles in that class—the Soviet SS-20 and the U.S. Army's Pershing-II—went on display in our "Milestones of Flight" gallery, marking a milestone of cooperation between superpowers.

Beyond making a whole variety of military rockets and spacecraft available to the Museum, the end of the cold war has enabled us to focus our scholarship elsewhere. In 1992, the department of space history opened a gallery that departed from typical Museum practice in that it looked into the future, as well as the past. "Where Next, Columbus?" optimistically focuses on the next 500 years of space exploration and discovery.

Like "Where Next, Columbus?" another of the department's recent galleries—"Beyond the Limits: Flight Enters the Computer Age"—introduces visitors to computer simulations and interactives, a relatively new kind of museum display, one that NASM has played a role in pioneering. Appropriately, last year "Beyond the Limits" became one of the first galleries to "go virtual": It was made available on the Smithsonian Institution's site on the World Wide Web (www.nasm.edu/GALLERIES/GAL213/gal213.html), enabling visitors to learn about exhibit artifacts from the comfort of their home computers.

Undoubtedly, there will be greater connectivity to the world by using

Join the Planned-Giving Program

Discover the wide array of charitable gift opportunities available at the National Air and Space Museum. Your support will help the Museum's efforts to build an extension at Dulles airport, which will display such artifacts as an SR-71 Blackbird and the space shuttle *Enterprise*. For more information, contact Tarrant Putnam, manager of planned giving, at (202) 357-4487.

IN THE MUSEUM

computers, including the possibility of a "virtual" Smithsonian, where visitors will be able to electronically tour Museum galleries, conduct research on artifacts, search for documents and photographs in NASM's archives, and look at real-time images from orbiting satellites—all without worrying about closing hours or getting cookie crumbs on the carpet. A sign of the incredible pace at which this technology is advancing is on display in "Beyond the Limits": Next to a see-through, floor-to-ceiling column containing one million 1960s-era transistors is a tiny box with a magnifying glass; under the glass is a microchip, which also contains a million transistors.

But there is, I predict, no danger that a "virtual" Air and Space Museum will replace the real thing. Early next year, the Corona satellite will join dozens of other extraordinary and unique artifacts in a major renovation of Space Hall, which will culminate in the opening of "The Space Race." This new exhibit will feature many never-before-seen objects left over from the cold war competition in space, including the spacesuit that the Soviet Union built for its failed mission to land a Russian on the moon.

What else might go on exhibit in the next 20 years? Friends of NASM may be interested to know that we have already asked the CIA for the successor to Corona, which only recently was orbiting over our heads. The folks at Langley have asked us to be patient. We will. In a museum, time is always on your side.

—Gregg Herken is chairman of the department of space history.

Museum Calendar

Except where noted, no tickets or reservations are required. To find out more, call Smithsonian Information at (202) 357-2700, Mon.–Sat., 9 a.m.–4 p.m.; TTY: (202) 357-1729.

June 1 Monthly Sky Lecture. "The Smithsonian Sun." David DeVorkin, a curator at the National Air and Space Museum, talks about the history of the Smithsonian's Astrophysical Observatory during the tenures of Samuel Pierpont Langley and Charles Greeley Abbot. Einstein Planetarium, 9:30 a.m.

June 8 Family Workshop: Make a Windshield Sun Cover. For Father's Day, give your father or grandfather a windshield sun cover with stenciled patterns of historic air- and spacecraft displayed in the Museum. Two sessions: 10 a.m to 11:30 a.m. and 1 p.m. to 2:30 pm. Materials fee: $10 per child. To register, call (202) 633-8926 or TTY: (202) 357-1505.

June 12 Exploring Space Lecture. "The Sky Is Falling: Impacts and Their Role in Planetary Evolution." Geologist Eugene Shoemaker, co-discoverer of Comet Shoemaker-Levy 9, examines past planetary impacts and their profound effects on Earth. Einstein Planetarium, 7:30 p.m.

June 15 Family Star Watch. To introduce children to the joys of stargazing, Cheryl Bauer of the Einstein Planetarium conducts a search of the night skies for delightful constellations. Einstein Planetarium, 10:00 a.m.

June 28–July 1 The Museum will offer "You Can Fly!" information centers, where visitors can learn about organizations that promote aviation.

June 29 "Taking Flight: Vicki Van Meter." Teenage pilot Vicki Van Meter talks about her aerial adventures: At age 11, she crossed the United States in an airplane under the watchful eye of an instructor, and later, she flew the Atlantic in a single-engine airplane. Pioneers of Flight gallery, 1:00 p.m.

July 1 The Commodores, a Navy band, will entertain visitors with a free concert. Air Transportation gallery, 3:00 p.m.

NOW SHOWING

JPL/NASA

Those who didn't get a chance to see Comet Hyakutake light up the sky last March should check out the Einstein Planetarium's newest show, "The New Solar System," in which images of comets abound. This latest offering from the Museum's planetarium is the most technically advanced production it has ever undertaken; the show seamlessly displays planetary images gathered by a slew of space probes and features plenty of animation and special effects. Following the path of a fictional comet, "The New Solar System" takes you on a planet-by-planet journey, starting with Neptune's moon Triton and traveling back toward the sun. Along the way are some unexpected sights: a sweet-looking rabbit nestled amid the flora of a developing Earth, a beeping Sputnik passing through the sky, and a simulation of a comet or asteroid slamming into the atmosphere over Siberia in 1908 (the collision is so bright it'll make you blink). But even without the 30-minute show, the chance to sit in a comfortable, reclined chair bathed by soft light is well worth the admission price of $4. At the end of the show, you won't want to get up.

On the Web

A spyplane pilot tells his tale on the *Air & Space/Smithsonian* Website (www.airspacemag.com/TWD/TWD0001.html). Read an interview with former SR-71 Blackbird pilot Tom Alison, who talks about the reconnaissance missions he flew over the world's trouble spots between 1974 and 1981. After retiring from the Air Force, Alison joined the National Air and Space Museum as a curator of aeronautics. Posted along with the interview are video clips of NASM's SR-71 making a high-speed pass and undergoing a midair refueling.

Fifteen years of microelectronic research makes conventional antennas a thing of the past!

This little box uses your home's electrical wiring to give non-subscribers, cable subscribers and satellite users better TV reception on your local broadcast networks!

by David Evans

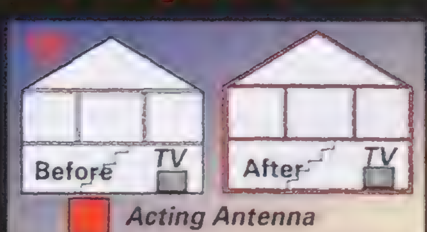
Technology corner

1. Why don't conventional antennas work as well as the Spectrum?

Bandwidth of TV Signal

- When TV signals are tuned at the TV channel's center frequency, optimum tuning has been achieved.
- Other antennas can't offer center frequency tuning like the Spectrum Antenna can. They only offer such tuning up to the edge of the center frequency. As a result your TV picture remains snowy.

2. How does Spectrum use a home's electrical wiring as an antenna?



Believe it or not, the Spectrum Antenna simply "activates" the giant antenna that already exists in your home. Essentially, it uses all of the wiring throughout your home's walls and ceilings to make an antenna as large as your house for unbelievably clear reception of local broadcasting.

3. Spectrum antenna features

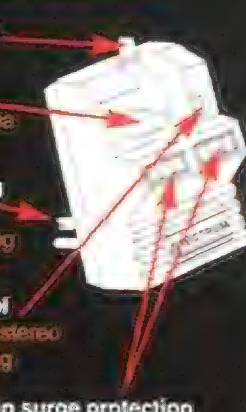
Parallel 75 ohm resistance
For minimum loss of signal

Signal search control
For selecting multiple antenna configurations

Polarized three-prong plug for grounding
For optimum signal grounding to eliminate noise and static

Resonant fine tuner control
For dialing in crisp, clear TV/stereo reception, eliminates ghosting

Dual AC outlets with built-in surge protection
For plugging in additional TV/stereo equipment guarding against damage and electrical surges



Until recently, the only convenient way to guarantee great TV reception was to have cable installed or place an antenna on top of your TV. But who wants to pay a monthly cable fee just to get clear reception, or have rabbit-ear antennas that just don't work on all stations? Some people just aren't interested in subscribing to cable. Or they may live in an area where they can't get cable and TV-top antennas aren't powerful enough. And what about those people who have cable or satellite systems but still can't get certain local stations in clearly?

Now, thanks to fifteen years of microelectronics research, a new device has been developed that is so advanced, it actually makes conventional antennas a thing of the past. It's called the Spectrum Universal Antenna/Tuner.

Advanced technology. Just imagine watching TV and seeing a picture so clear that you'd almost swear you were there live. Just plug the Spectrum Antenna into a standard AC outlet and plug your TV into the Spectrum. You can remove the unsightly clutter of traditional TV-top devices gathering more dust than television signals. Get ready for great reception. Your TV will suddenly display a sharp, focused picture thanks to its advanced design "Signal Search" and "Fine Tuner" controls.

Uses your home's electrical wiring. The Spectrum Antenna is a highly sophisticated electronic device that connects into a standard wall outlet. The outlet interfaces the Spectrum Antenna with the huge antenna that is your home wiring network. It takes the electrical wiring in your house or apartment and turns it into a multi-tunable, giant TV reception station which will improve your TV's overall tuning capability. The results are incredible. Just think how much power runs through your home's AC wiring system—all that power will be used to receive your local broadcasting signals.

How it works. Broadcast TV signals are sent out from the local broadcast station (ABC, CBS, NBC, etc.). They interface with your home's AC power line system, a huge aerial antenna network of wiring as large as your home itself. When the Spectrum Antenna interfaces with the AC line, the signal is sent to its signal processing circuit. It then processes and separates the signal into 12 of the best antenna configurations. These specially processed signals route themselves into 12 separate circuits. The Spectrum Antenna includes a 12-position rotary tapping switch, the "Signal Switch" control, which gathers twelve of the best antenna configurations.

The "Signal Search" offers varying antenna configurations for the user to select from the best signals of all those being sent. The signal then passes through the Spectrum Antenna's special "Fine Tuner" circuit for producing crisp, clear reception.

Risk-free offer. The Spectrum Universal Antenna/Tuner comes with our exclusive 90-day risk-free home trial and a 90-day manufacturer's warranty. Try it, and if you're not satisfied, return it for a full "No Questions Asked" refund.

Who can use Spectrum?

- *Cable users-You have cable but you can't get certain local stations in clearly.*
- *Non-cable users-You don't have cable and want the stations to come in more clearly*
- *Satellite users-You have a digital satellite system but can't get local stations in clearly*

Limited time offer! We realize that most people have more than one TV in their home. We are offering a special discount on additional Spectrum Antennas so you get great reception on all your TVs!

Spectrum Antenna ....$39 $4 S&H
Additional antennas just $34 S&H free

Please mention promotional code **1493-AM-1100.**

For fastest service, call toll-free 24 hours day

800-992-2966

comtrad industries
2820 Waterford Lake Drive, Suite 102
Midlothian, VA 23113

Heart Breaker

We would have preferred a darker sky, but at least the brightness of the third-quarter moon let us read our watches. That was just as well, because most of us kept pushing up our heavy sleeves to check the time. The physics of orbital mechanics is quite particular about timing.

It was Saturday, this past March 9, 5:30 in the morning, and the beach at west Galveston, Texas, was cold. We had arrived one, two, or three at a time, most of us having traveled 30 miles or more from our homes, because we felt compelled to witness a celestial event that was, in part, of our making. As we paced around on the sand, exchanging quips and doing our best to keep warm, we knew all too well the irony of our situation: All of us wished we hadn't been given this opportunity to view the impending spectacle.

About two weeks earlier, the crew of the space shuttle *Columbia* had released the Tethered Satellite System (TSS), part of a joint effort between the United States and Italy. The half-ton Italian satellite was to be deployed on an electricity-generating tether more than 12 miles long. Had the mission gone as expected, the crew and scientists on Earth would have conducted extensive experiments in space plasma physics and power generation during the two-day deployment before the shuttle crew reeled the satellite back into the payload bay.

As the world now knows, however, for an as-yet unknown reason the tether broke only about half a mile short of full deployment. The break was at the shuttle end, which meant two things: The crew was in no immediate danger of a recoiling tether, and, thanks to the physics associated with orbiting tethered objects, the satellite, trailing a nearly 12-mile tail, received a free boost into a sizably higher orbit. Since that gave the satellite and tether an orbital life of a little over three weeks, far beyond what had been planned, we in Houston now had the opportunity to see what

PAUL SALMON

otherwise would not have been visible in North America.

Those gathered on the beach shared a unique bond. We were part of the NASA engineering team that had developed the techniques required to deploy and retrieve a tethered satellite. Twice now we had suffered the disappointment of seeing mechanical problems prevent the testing of most of our retrieval techniques during flight.

The satellite first flew aboard the shuttle in August 1992. During the deployment, TSS-1 jammed at 256 and 840 feet. The last jam ended the deployment. From that relatively short length, retrieval dynamics weren't really a problem, although some clever work was required to clear the jam and recover the satellite.

When the tether broke four years later, on mission STS 75, recovery of the satellite, though evaluated, was never attempted. Involving a shuttle re-rendezvous and spacewalk, it would have been risky at best, but the main obstacle proved to be the propellants. There was no guarantee there would be enough to both safely retrieve the satellite and conduct the rest of the flight. (The incident demonstrated almost too well the tether's potential in the application of orbital boost. When the tether broke, the maximum altitude of the satellite's orbit was almost instantly increased by over 72 miles. If the shuttle had had to deliver the satellite directly to that orbit, it would have needed to burn nearly one and a half tons of propellant.) Our disappointment seemed all the darker when it stood starkly against the elation that preceded it: Prior to the break, the satellite, deployer, and shuttle had been performing flawlessly. I think that this was, in part, why our gathering here in the early morning hours seemed almost a necessity.

This is the real story of military flying. The incredible, bone-jarring crashes. The miraculous tales of survival. The gauntlet of SAMs, triple A, and ground fire on the target run. Once-in-a-lifetime landings. Life or death struggles for control off the carrier deck. Horrifying ramp strikes. "Cold cats."

You can't imagine all the ways a flight can go wrong. *Locked controls. Burning tires. Flat spins.* It's all here in a remarkable new video series that deserves a prominent space in your home library.

Near-misses. Close calls. Mishaps that pilots have talked about for years. Culled from thousands of hours of classified military footage – released here for the first time.

For a limited time, you can order a special preview of the first twelve episodes of *The Challenge of Flight* series. You'll get a complete collection of mishap footage — The first crashes on the deck of the USS Langley. The incredible F-100 "Sabre Dance". The horrifying F9F ramp strike. And the crash of the first awesome F-22.

Each episode looks at a specific area of flight — *Takeoffs. Landings. Ejections. Bomb runs. Air-to-air weapons* — and is packed with the kind of gripping footage that everyone wants to see. Pilots. Military collectors. And anyone who thrills to adventure.

Call our toll-free number now and tell us you want to preview The Challenge of Flight for only $5*, and we'll include a pair of Aviator Sunglasses with Case – free!

A brand-new, exciting episode will be shipped to you about every six weeks for only $19.95.* If you are not completely satisfied, just cancel at any time, or return any tape within 60 days for a full refund. Your satisfaction is guaranteed or your money back. Preview *The Challenge of Flight* today. Call now!

1 800 591-7100

☐ Please send me a preview video of *The Challenge of Flight* series and Aviator Sunglasses with Case for just $5.* plus $3.75 S & H. (AS2-AS)

Name

Address

City

State Zip

Telephone

Payment Method ☐ ☐ ☐ ☐

Card # Exp. Date

Signature

USFS, 14101 NW 4th Street, Sunrise, FL 33325

Visit us on the World Wide Web at **http://www.usfs.com**

The use of long tethers—those longer than a kilometer (two-thirds of a mile)—in space is not a particularly new idea. Numerous applications have been proposed for both orbital and interplanetary tethered systems (see "The Peculiar Behavior of the Heavenly Funicular," Oldies & Oddities, June/July 1992). One is the generation of electrical power, which can be produced by simply orbiting a conducting wire through Earth's magnetic field. The ability to provide orbital boost and deboost, derived from the imbalance between gravitational attraction and centrifugal acceleration at both ends of a tether, promises to conserve immense quantities of propellant in future space transportation systems, possibly even in space station operations.

However, until the last decade or so, the idea of long space tethers had remained primarily a theoretical concept—with one notable exception. The space historian in me must pay homage to the first-ever space tether experiments. Tests evaluating the gravity-induced stability of orbiting tethered objects and the rotational generation of artificial gravity were conducted during Gemini 11. But even participants in those experiments would admit that the hardware was rudimentary at best. The tethers used were actually 100-foot straps, similar to car seat belts in appearance, and they were jettisoned once the experiments were complete, requiring no reel-in. The Gemini team learned much, but much more remained to be discovered.

Consequently, we still needed to prove that long tethers could be deployed and retrieved from an orbiting spacecraft, and that required developing the procedures and flight techniques. In turn, we needed to develop the team and tools necessary for monitoring deployment, retrieval, and all associated dynamics of the satellite and tether. Finally, we had to design and complete the training of the crew and flight control team to ensure they could execute a test flight that might present any number of possible scenarios. Not since the Apollo program had so many aspects of a spaceflight been developed with no precedent.

My responsibility (which I shared with others, of course) was to train the crew and flight control team to monitor and control the interactive dynamics of the shuttle, tether, and satellite. Training for the first mission was especially challenging. We felt that we were barely keeping pace with the latest technical information concerning this or that flying technique or newly discovered potential dynamic tether mode. We learned during the development of our training software that the tried-and-true Shuttle Mission Simulator—which had always been perfectly adequate for training for the orbital mechanical aspects of rendezvous and proximity operations—could not process the software needed to simulate the potential tether dynamic behavior we were most concerned about: skiprope. In skiprope, the tether rotates like a jump rope between the shuttle and the satellite, and if the phenomenon developed during flight and the crew and team could not damp it, recovery of the satellite would likely have been impossible. Yet despite the frustrations, despite the ridiculously long hours, we were drawn to the challenge of it all. The need to be innovative at every turn compelled us to march on because it felt so damn good to blaze so many trails.

After all our efforts to perfect the techniques for damping skiprope and recovering the satellite from the tether's fully deployed length, we were crushed when the TSS-1 deployment stopped short. Once the satellite had been recovered, however, we knew that a reflight was a possibility and began looking forward to TSS-1R (the "R" is for reflight). Early on we kept tabs on every rumor of where on the manifest the reflight might be placed. Eventually, it landed alongside a suite of microgravity experiments on STS 75, slated for launch in early 1996.

PAUL D. MALEY

Viewed through a portable low-light television system, the Italian satellite, its 12-mile tail hanging beneath it, traverses the Houston sky. NASA contractor Paul D. Maley first filmed the TSS in Australia. However, his favorite images, including this one, were shot almost literally in his back yard, near Johnson Space Center—one small benefit of a mission gone awry.

Even before the flight assignment was certain, we began to lay the groundwork to do the next TSS mission even better. And it wasn't only the flight controllers and instructors who came back to fly it better the second time: In an unprecedented reassignment, five members of the STS 46 crew were selected to fly on STS 75. They too shared the dynamic team's special bond.

We knew that we had assembled some very good concepts for the first TSS flight, but STS 46 taught us that our tools and techniques needed improvement. With a four-year lead time for the reflight, we set out to improve on them. We redefined the structure of the operations team. We enhanced the software for monitoring shuttle, satellite, and tether dynamics. We rewrote crew procedures and developed new onboard computer tools. And finally we designed, implemented, and executed an entirely new means of training for skiprope dynamics management.

As the flight approached we all felt confident that this time we had done it right, to the absolute best of our abilities. The team and crew of STS 75 were ready to deploy and—especially—retrieve, the Tethered Satellite System.

But once the crew reported that the tether had broken—at approximately 7:30 p.m. Central Standard Time on February 25—the dynamics team members were left with little to do beyond capturing their data to support the inevitable investigation. I felt compassion for the crew and the rest of the flight control team—they had to complete almost two more weeks of microgravity experimentation while dealing with their disappointment. At least we on the dynamics team could track down a restaurant that was open at 11:00 p.m. on a Sunday night so we could gather and ponder the events of the evening and what had gone before.

Much of what we thought went unsaid because we had shared so much of it for so long. We knew, of course, that developing and executing entirely new operational schemes entailed the risk of failure. We also knew that the potential for failure is a part of developing technology—and this inspired us to be that much more thorough when we tackled the what-ifs and wrestled with the possible flaws in our thinking. The disappointment we felt must have been similar to that experienced by the first engineers in this business, when the rockets kept blowing up. One major difference between then and now was apparent to us, however.

In the midst of the cold war and with the presidential mandate of a race to the moon imposing a deadline, space program engineers then had to come back to work the day after any technical setback and determine the cause of the failure immediately; there would be another launch to support a month or so later. By comparison, the current shuttle launch manifest, laid out into the next century, doesn't have a TSS-2 or TSS-3. We who are compelled to help move this technology forward wonder: In a society

THE BIG SWEEP

Minesweeping by helicopter is a real drag, punctuated by occasional ugly surprises.

by Michael Alves

Photographs by Sam Sargent

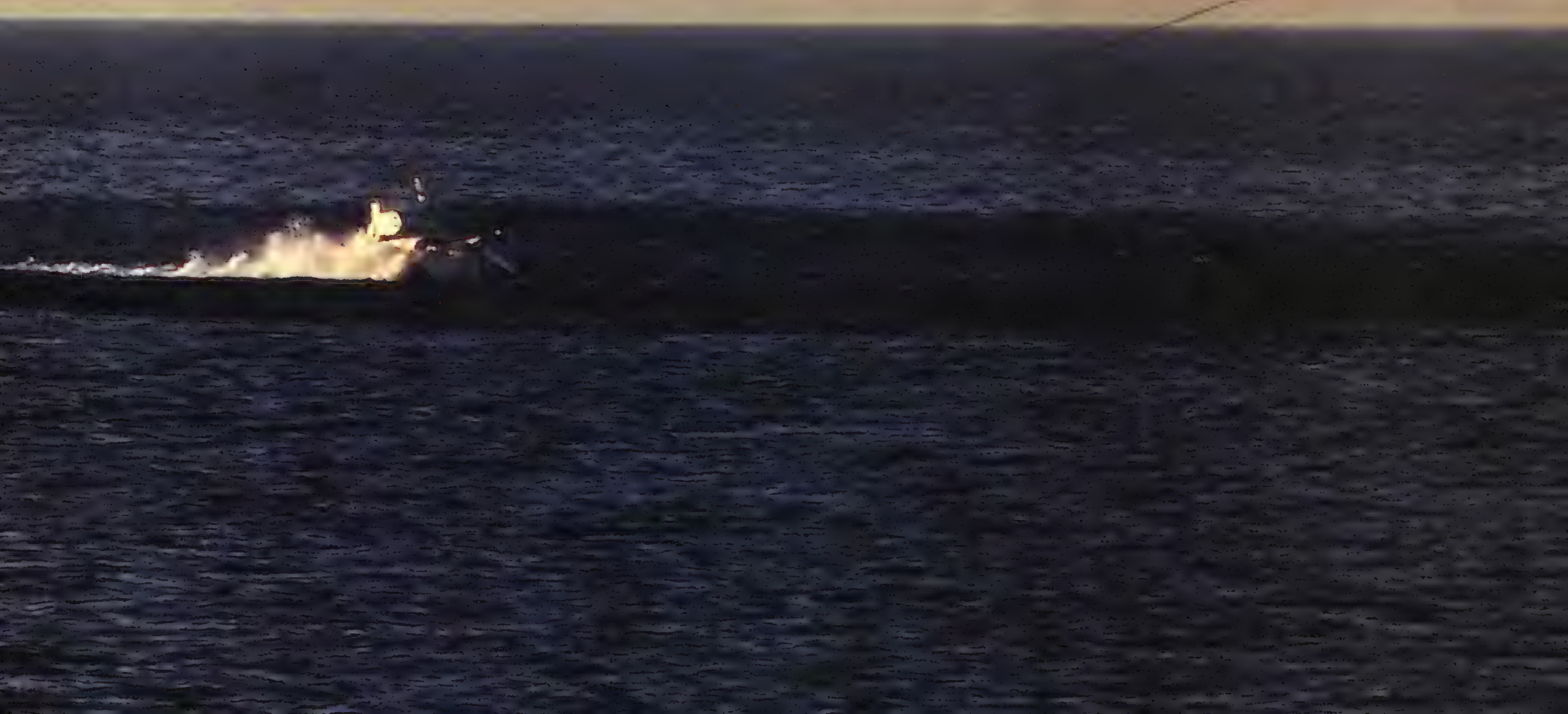
The wakeup call came early and loud. "It was 4:32 in the morning," recalls Navy commander John Vuolo. "I was getting ready for a five o'clock brief. I'd just come off the head, and I heard this scraping alongside the ship. And I go to myself: *No way*. And KA-BOOM!" It was one of the mines his helicopter squadron had been sent to hunt off the coast of Kuwait.

It was a bad start to a long week for the USS *Tripoli*, the flagship of Allied mine countermeasures in the Persian Gulf war. It was only Monday, and already the *Tripoli* was trapped in a minefield with a brand-new $4 million hole in its side.

With the first rays of dawn fighting through the soupy, humid air and the dense smoke of Kuwait's burning oil fields, Vuolo lifted his Sikorsky MH-53E Sea Dragon helicopter from the *Tripoli*'s flight deck. Flying at 75 feet and about 12 mph, in visibility so bad he couldn't see past the end of his refueling probe, Vuolo and his sweat-drenched crew spent four hours towing hundreds of feet of cable-cutting equipment back and forth through the water in an attempt to separate the deadly mines from their anchoring chains so they would come to the surface. There, divers neutralized them, attaching explosive charges to the mines, then setting them off by remote control.

Eventually Vuolo, his fellow pilots, and minesweeping ships were able to clear a path to free the damaged *Tripoli*. But Vuolo can tell you that a minesweeper's work is never done. At the end of Desert Storm, for instance, only about half of the 1,000 mines known to have been planted by Iraq in the waters off Kuwait had been found and destroyed. And as Captain Robert O'Donnell, commodore of the Navy's Mine Countermeasures Squadron Two, says, "It doesn't even take a mine to make a minefield. All you have to do is tell people you planted mines and you can stop ships."

In the United States, the airborne mine countermeasures mission falls to two Navy squadrons, one in Norfolk, Virginia, and the other recently relocated from Alameda, California, to Corpus Christi, Texas. The Norfolk squadron, HM-14



that puts so much emphasis on risk-free investments and is content to explore the unknown via *Star Trek*, will *we* be on the team that finally does retrieve a tethered satellite? Perhaps that uncertainty was the true source of the deep disappointment we felt in that haunting moment when the crew reported that the tether had broken.

We looked skyward, just above Scorpio, each of us shielding our eyes from the moon's glare. Suddenly someone called out, "There it is! To the right of the moon!" Quickly, we all turned to follow the uplifted hand and then stood very still, stunned at the sight high above us. The length of two full moons, the apparition glowed a ghostly whitish-gray against the dark blue sky as it raced, vertically aligned, across the stars. We could all clearly distinguish the satellite as a bright spot at the top end. With binoculars some of us could resolve a slight curve along the bottom tenth of the tether. We each shouted out our impressions as it quickly crossed our small patch of sky. Gradually, as the geometry of beach and tether and light became unfavorable, the tether's brightness began to fade. Shouts now were to acknowledge losing sight of it; those with binoculars had it a few precious moments longer than the rest. Finally, it disappeared into the background glare of the rising sun. Less than five minutes had passed.

Those of us on the beach had found some comfort in this unexpected reward, but we hoped then and hope now that someday our true reward will arrive. This will be the opportunity to put our techniques, tools, procedures, and training plans to work on the next deployable and retrievable tether flight.

How have we kept our fascination alive on such a long, slow journey? I really can't say. I do know, however, that our fascination will endure. I was assured of this less than one hour after our gathering had broken up.

As we reconvened for breakfast at a Galveston hotel, our conversation rarely drifted into melancholy about what might have been. Instead, we discussed various subjects, including items as mundane as where this or that person happened to be living at the time or our trials with the latest upgrade of software at the office. But the conversation was never as animated as when someone brought up SEDSAT. SEDSAT is the only tethered mission currently manifested on a shuttle flight, slated to fly a year from now. Although this mission is quite a bit simpler than TSS and does not involve a tether retrieval, it does involve a tether deployment technique that has never been executed from a manned spacecraft.

On to the next flight!

—Robert J. Mahoney

JOHN KACHIK

After reading a 694-page manuscript for a novel by actress Joan Collins (best known as Alexis Carrington on the 1980s TV series "Dynasty"), her editor at Random House decided it was "primitive," "disjointed," "clichéd," and unpublishable. (An example: "There had never been a moment's doubt in her mother's or anyone else's mind, that Laura Marlowe possessed outstanding loveliness. Heart shaped, creamy skinned, the oval symmetry of her face was framed by a cloud of golden hair whose curly tendrils caressed sculpted cheekbones, a perfect pointed chin and a flawless forehead. Her enormous eyes, guileless and innocent as Botticelli angels were the pale blue of a midsummer sky, and her retroussé nose was perfection.") Random House wanted to reclaim its $1.2 million advance, but a Manhattan jury decided last February that the author-actress had in fact lived up to the terms of her contract and was entitled to keep the advance. Seeing that Collins' purple prose had paid quite a bit more than did his own work, aerospace historian and contributing editor William E. Burrows fancied publishing his research in Collins' style.

There had never been a moment's doubt in his mother's or anyone else's mind that Sergei Pavlovich Korolev possessed formidable ruggedness and an iron will that no one could resist. Square-shaped and ruddy-skinned, the blockish symmetry of his impassive granite face was framed by ears shaped like radar dishes and a Siberian forest of hair like a brown bear's that crowned a forehead as furrowed as the Smolensk beet fields from which he had sprung, a nose that drew its flame from a body marinated in vodka, and a square chin that knew how to take it. His always-suspicious eyes, as wary as a Siberian tiger's, were large and round and glowed like the sun that caressed Ukraine in summer and radiated relentless uncompromising genius and charisma. The young and driven Chief Designer of the Soviet space program missed nothing!

Now he watched Katya Felina as she walked across the design bureau's conference room toward him, her slim fingers wrapped around a cylindrical steel model of the R-7 booster's upper stage. The tiger looked hungrily at her proud Byelorussian breasts, his blood surging like hot borscht in a samovar. Then he thought about Premier Khrushchev. God, how he detested that bloated lout and all he stood for! But the old bastard—a peasant to his marrow—and his lackeys in the Politburo were cows to be milked to nourish the dream of a Mars landing, a dream that could never be extinguished. Korolev's soul would forever be possessed by the Red Planet! Then Katya Felina spoke.

"We need more thrust, Sergeiev." Her pale blue eyes, the color of the wispy cloud-dappled sky in the early morning over Yakutsk, bored into him like pulsating corkscrews as she leaned over his desk, her booted leg rubbing against his wooden chair until it creaked in agonized surrender. "We need a higher specific impulse or this pig will never make it off the ground and we will never beat that Nazi slime who serves his American masters," Katya Felina purred as she caressed the cylinder and smiled cruelly. "And," she added, "we will need to increase the sustainer's thrust with the skirts off. The skirts *must* come off, Sergeiev, and the thrust *has* to be increased. Do you understand?" she pressed, sighing a long sigh.

"Kerosene and liquid oxygen have only so much to give," the tiger growled in annoyance as he stared, transfixed, at the silver Cossack pendant hanging in stark relief against a soft woolen sweater so black it reminded him of midnight on the steppes of Central Asia. She smelled of sweet Russian tea and tobacco and the barest hint of the fragrant perfume the Tashkent natives made from potato blossoms in early autumn. *This woman is a matrushka doll*, Korolev decided, his eyes narrowing almost imperceptibly. *A box within a box.*

"I *too* have only so much to give," she said at last.

Last December, the HM-14 squadron spent a week off the coast of North Carolina practicing towing "the sled"—a platform that drags charged wires through the water, tricking any mines present into spending their charges harmlessly.

DEFENSE VISUAL INFORMATION CENTER/MARCH AFB

The mine that did $4 million in damage to the USS Tripoli *during the Gulf war cost the Iraqis only $1,500.*

(HM stands for "Helmineron," military shorthand for "Helicopter Minesweeping Squadron"), has multimillion-dollar simulators for both crew and pilots, but two or three times a year squadron members fly off for a training exercise under more realistic circumstances. Last December, one was held 50 miles off the coast of Jacksonville, North Carolina, in a slice of the Atlantic Ocean called Onslow Bay, where the Navy had sown dummy mines.

Part of a much larger naval exercise, the week-long training required dozens of three- and four-hour missions from ship and shore in which crews practiced towing and operating minesweeping and mine hunting systems.

The sweeping equipment that the Navy uses falls into two classes. The first, the kind Vuolo and his crew used off of Kuwait, is for contact mines—explosives that are set off by physical contact with a ship passing over them. The current version of the countermeasures equipment hasn't changed much since World War I. Basically, it consists of a pair of long float-supported wires that when towed flare out into a giant "V" underwater. The wires guide a mine's mooring cable into the jaws of explosive cutters spaced along the wire's length.

The other class of minesweeping gear is designed to work against mines that are set off by the sound or magnetic signature of a passing ship. These "influence" mines can be either scattered along the ocean floor or tethered, but the tethered ones are much deeper in the ocean than contact mines, so they are harder to unmoor. To sweep for influence mines, the Navy uses another kind of gear, one that gives off a signal—either acoustic or magnetic—that simulates a passing ship. And if the signal is accurate enough, the mine wastes itself in a harmless show of force.

Last December's exercise gave HM-14 a lot of tow time with "the sled"—a platform trailing two long, electrically charged tails. The charge creates a magnetic field, and any mines present will interpret the field as the magnetic signature of a ship's hull. For a more complete sweep, another device can be attached to one of the tails. This "noisemaker" is essentially a float with a small funnel that sucks in water; inside, a disk churns the water to simulate the sound of a ship's cavitating propellers. (Because

At HM-14 headquarters, both pilots and crew members have simulators for practicing minesweeping operations.

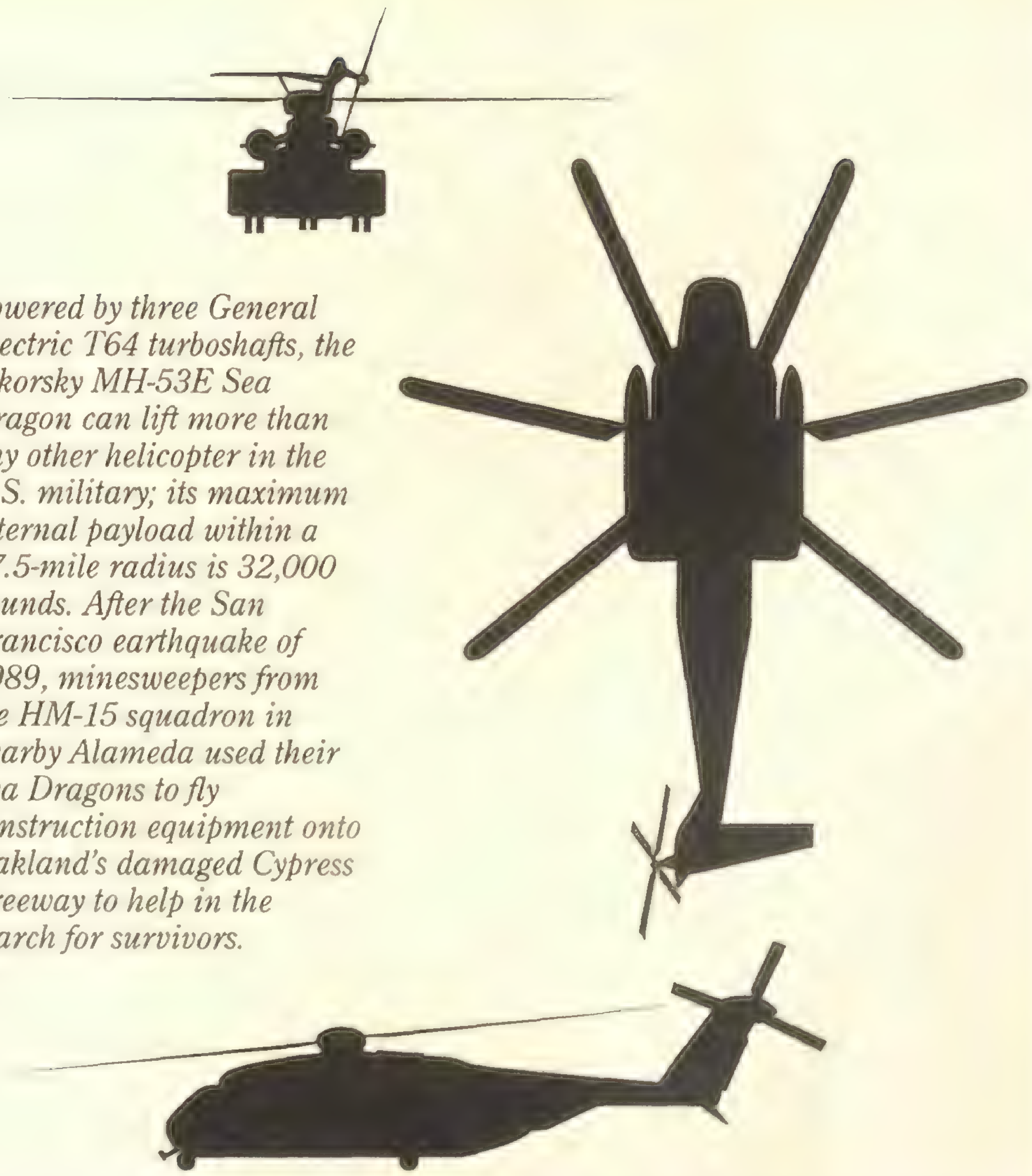
the cables and noisemaker are dragged far behind the sled, any mine explosions they set off usually leave the sled unharmed.)

One clear, bright morning, helicopter no. 554 slowly dragged the sled out of the bowels of the USS *Nashville*, a ship the squadron had borrowed to use as staging base. Lieutenant Ed "Fast Eddie" Fassnacht, pilot in command, and copilot Lieutenant Mike Rein gingerly edged their Sea Dragon away from the ship while sailors on a fleet of small Zodiac-type boats tended to the sled.

For the first 25 minutes after takeoff, there was a lot of discussion over whether the MK-104 acoustic device had been properly attached. Then the crew settled into their jobs, their gunner's belts clipped to various hooks and wires to keep them from accidentally exiting through the aircraft's wide open rear door. "Sooner or later it happens to everybody," says Frederick Marshall, a maintenance chief with HM-15 and an experienced flier. "You work in back and you forget where you are for a moment and you find yourself hanging by your gunner's belt. The time it happened to me they just reached out, grabbed me, and hauled me back in," he says matter-of-factly.

On this exercise, both pilots and crew strapped on bulky survival vests that weighed around 20 pounds apiece, including small tanks with a couple of minutes' worth of compressed air to use in the event the helicopter went down. Because they're top-heavy, most choppers that go into the water promptly roll over unless they have flotation gear, which minesweeping MH-53Es don't carry. The Navy uses barrel-shaped simulators—universally disliked for their verisimilitude—to train pilots and aircrew in the best way to get out of a sunken helicopter. Every four years you've got to show you can survive at least four dunks—two while wearing blackout goggles—or you don't fly (see "Survival 101," Oct./Nov. 1992).

The helicopter's first crewman, Aris-



Powered by three General Electric T64 turboshafts, the Sikorsky MH-53E Sea Dragon can lift more than any other helicopter in the U.S. military; its maximum external payload within a 57.5-mile radius is 32,000 pounds. After the San Francisco earthquake of 1989, minesweepers from the HM-15 squadron in nearby Alameda used their Sea Dragons to fly construction equipment onto Oakland's damaged Cypress Freeway to help in the search for survivors.

During a sweep, crew members keep an eye on the skew—the alignment of the towbar with the centerline of the helicopter. A misalignment can knock a crew member overboard.

tides Restituyo, oversaw all the crew's equipment checks for the mission, including testing of the fuel transfer system. Although it's towed, the sled needs fuel for the small gas turbine engine it carries. The turbine, a Garrett-AiResearch T76 (the engine that powers military OV-10 spotter planes), drives a generator that provides the 2,000-amp current flowing down the sled's two trailing electrodes. It has its own fuel, but if need be, the tow line connecting it to the helicopter can double as a fuel hose, so the sled can be refueled from the helicopter's tanks.

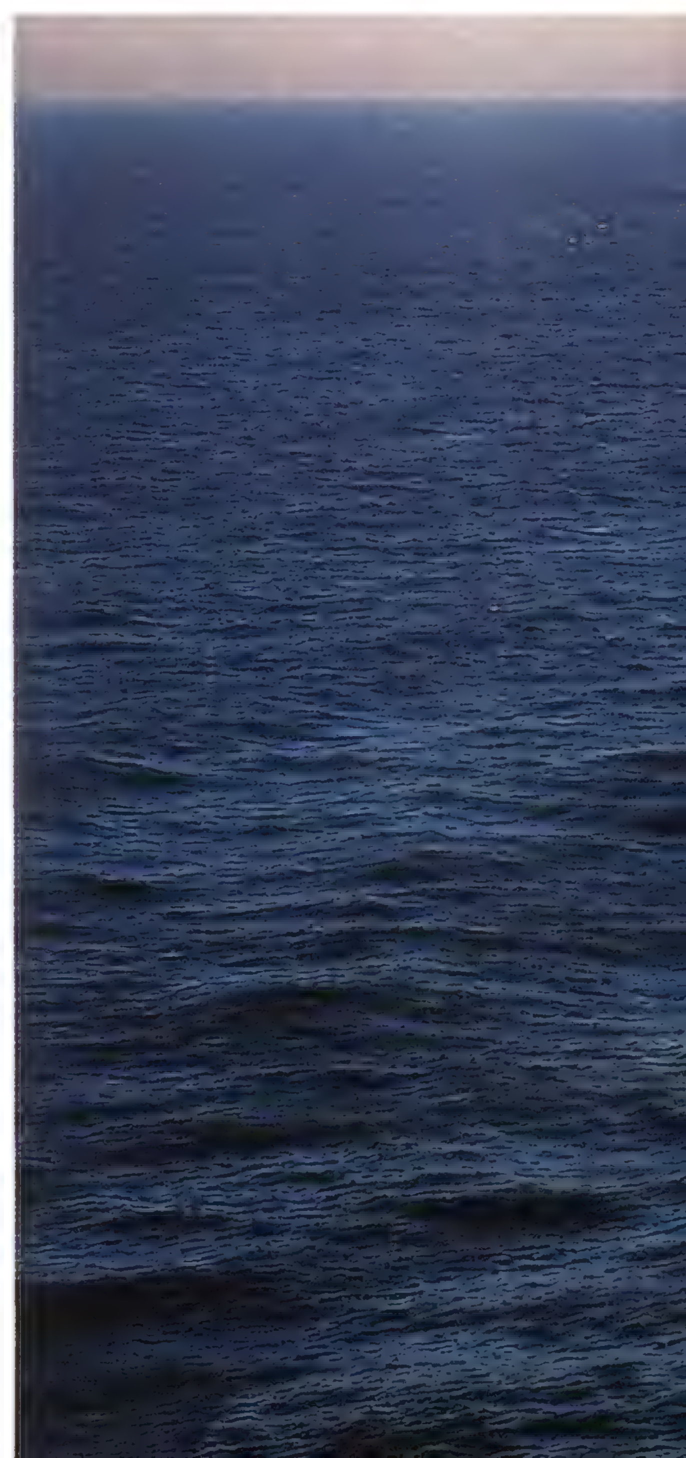
Balancing himself against the twitching towbar—the arm that holds the ball to which the tow cable is attached—Restituyo, who like most crewmen usually has many more hours "under tow" than the pilots he flies with, watched with a practiced eye as choppy waves washed over the sled's hydrofoils a hundred feet below. In the aircraft's cabin, the tow cable that connected the helicopter to the sled 450 feet behind jerked and tugged like a leash pulling along a reluctant dog. Somehow, it was a reassuring sensation: You got the feeling that if the sleds weren't available, the helicopter could tow a whole ship. Actually, looking at the thick-set Restituyo, you could picture him doing the job himself.

The pilots on minesweeping missions must fly arrow-straight tracks back and forth, often for miles at a time, so that every inch of a suspected field can be accounted for. But the helicopter is often buffeted by wind and by the motions of the sled in the waves below. Towing a sled on a straight path in these conditions forces the pilot to put the helicopter through all kinds of angle and attitude contortions. Lieutenant Joel Johnson of HM-14 notes that in flight school pilots are normally taught to fly what are called coordinated turns, in which the aircraft is neither slipping in toward the turn nor skidding out away from it. But in minesweeping flights, keeping the tow equipment on track requires the pilot to make these kinds of slips and skids regularly, even in straight and level flight. In pilot's jargon, he must fly "with the ball out," that is, with the instrument panel's coordination ball off-center.

When one track is completed, the helicopter executes a turn to proceed down the next. Nearly 1,000 feet of flying and floating machinery—from the helicopter to the end of the sled's magnetic tail—has to be kept as straight as possible. A properly executed turn is like a pivot on a point, with the helicopter slowly slewing around like the hand on a clock. During turns, the helicopter and the sweeping equipment may move closer together; to make sure the sweeper doesn't set off a mine while the helicopter is nearby, the crew makes its turns outside the field.

Because the flying was so demanding, 554's pilots frequently handed it over to the autopilot, whose computer had been programmed with the exercise's precise tracks. But, like human pilots, the autopilot has its limits; too many inputs on its sensors and it shuts down. Fassnacht and Rein had to watch

Between exercises, HM-14 stored and maintained its sleds on the Nashville. *Since their jet engines are immersed in corrosive saltwater during missions, flame-outs are a constant problem.*



Sweeping Through History

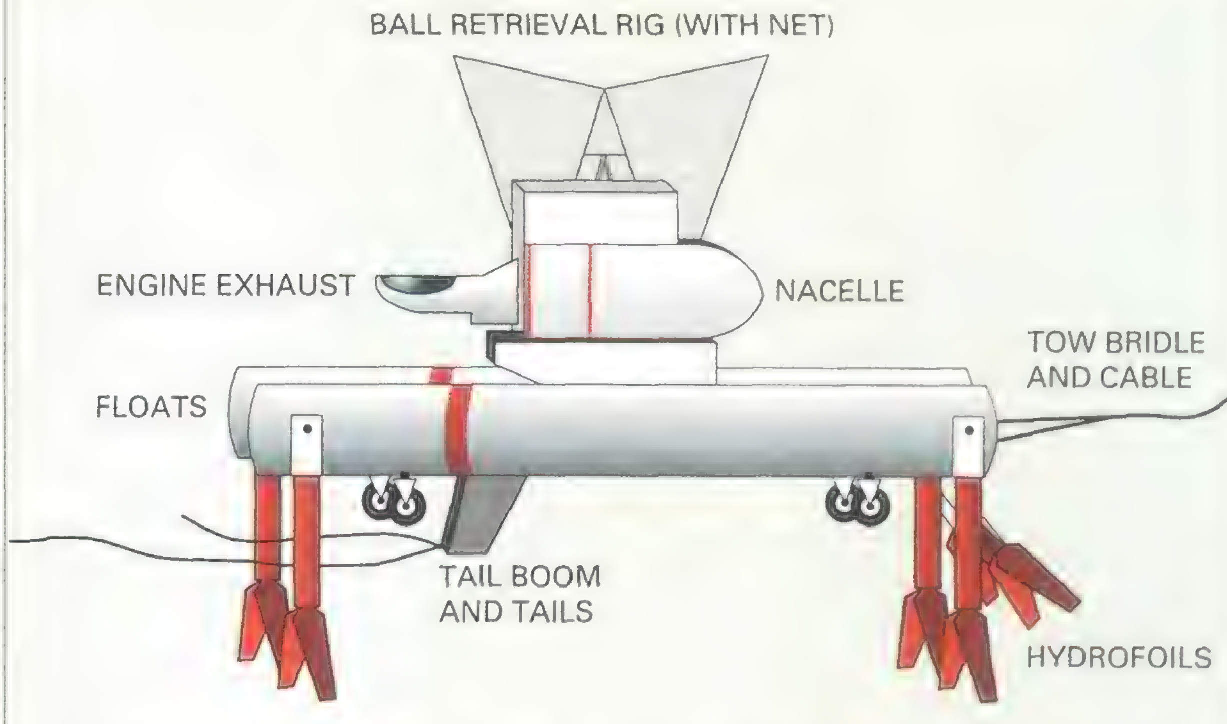
Besides early spotting sorties, aircraft were first used directly against mine threats during World War I, when the British discovered that air-dropped explosives would set off a few of the 57,000 mines that U.S. and British ships had dumped in the North Sea. In the next world war the Brits pursued airborne mine countermeasures more deliberately: They equipped four Mk-IA Wellington bombers with electrically powered magnetic coils that, when flown low over the water, were able to set off German mines sensitive to magnetic fields. For their part, the Germans were tinkering with their own flying mine magnets. In 1939, Ju 52s were adapted for the role. (Flying these "Mausi" missions, as they were called, must have been nerve-wracking. The first, over Vlissingen Harbor in the Netherlands, was flown just 30 to 60 feet above the water. Had a mine gone off a second or two sooner than hoped, the resulting waterspout would have blown an airman out of the sky.) The Germans also equipped the Blohm und Voss Ha 139 floatplane and BV 138 flying boat with magnetic rings for setting off mines.

The United States didn't start seriously experimenting with airborne mine countermeasures until 1951, when the Navy began testing helicopters as minesweepers. By 1952, a Piasecki HRP-1 helicopter had shown that it could tow a cable, cutter, and float arrangement called Oropesa, which freed mines from their moorings.

Advancements came slowly over the ensuing years, says Jerome Polon, an engineer with the EDO Corporation who helped develop the MK-105 sled for use in Vietnam. Polon adds that minesweeping equipment hasn't changed much since those days. The helicopters are bigger and the sweepers put out more current, but otherwise, he says, "we've had most of this stuff for a long time."

it carefully, again and again coaxing it ever so gently back to pulling the sled on the precise track. Deviations from the track are measured by the onboard global positioning system navigation equipment and shown in a video game-like display that tells the pilot where the helicopter is and where it should be. The autopilot's computer "just gets you in the ballpark," explained Rein.

Unfortunately, according to most minesweeping pilots, the autopilot starts bowing out of the ballpark with frequent regularity just when the wind starts blowing and the waves start churning. That's when every minesweeping crew really starts watching the skew—the position of the towbar in relation to the centerline of the helicopter. Since the towbar swings freely inside the helicopter, the pilot has to keep it aligned with the center of the helicopter or a nasty collision of boom, wall, and crewman will result—followed by the crewman and a section of the boom ending up outside the aircraft.



At the start of a mission, the MK-105 sled rides the water on its floats. As the helicopter picks up speed, the sled rises up until it is riding on its hydrofoils; this reduces the sled's drag, making it easier to tow.

The sled's nacelle houses a turbine-driven generator, which produces an electric charge for the tails.

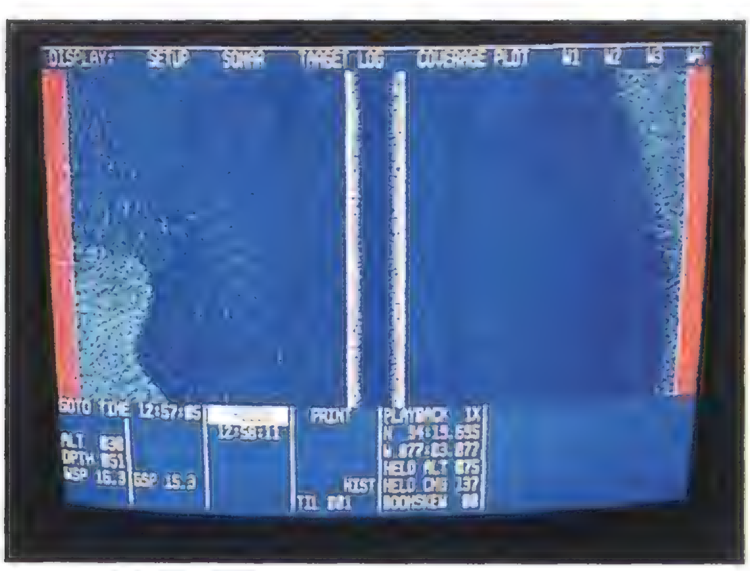
Should the sled become detached from the helicopter, the crew can retrieve it by dropping a tethered ball into an anchoring socket on the sled (the net atop the sled helps guide the ball into the socket).

Windy days are when the pilots really earn their flight pay. Managing a minesweeping helicopter is like juggling, says Captain Gary Tornatore, who flew them for years. "All the different things you have to watch: the gear, your skew, your speed, the track, your altitude, your tow tension, crosswinds, waves. It's just adding more balls to the act."

As the crew of helicopter 554 swept for mines, a Sea Dragon in another section of the long field practiced hunting mines with a "fish," an underwater side-scanning sonar device. The choppers first tow side-scan sonar devices through the water to determine if any mine-like objects are present. The crew lowered the fish into the narrow "null zone" of rotor wash below the helicopter so it wouldn't twist its tow cable like a yo-yo on the end of a string. Once in the water the fish was rapidly reeled out, and as the helicopter slowly picked up speed, the device flew through the water just above the ocean floor. In the chopper's cargo compartment, the fish's operators watched a real-time video of the sonar scan, recording the grainy movie on videotape for later analysis.

Landing on the small flight pad of the pitching Nashville *required precise flying (right).*

Airborne mine countermeasure missions start with crews searching an area with a "fish"—a side-seeing sonar device (bottom). In the image below, the tape made by the fish shows a possible mine in the lower left corner.



Most of the pilots in airborne mine countermeasures admit that flying minesweeping helicopters wasn't their first career choice. John Vuolo, who helped clear a path to free the *Tripoli* during the Gulf war, is a rarity: "I wanted to fly minesweepers since the first time I saw them," says the Annapolis grad, who commands minesweeping squadron HM-15.

Vuolo concedes that "there's no clear career path in this field," adding: "I didn't get into [minesweeping] to make admiral." Good thing: Even though airborne minesweeping has been practiced for years (see "Sweeping Through History," p. 28), the Navy has no flag-rank officers with direct experience in it.

So what satisfactions can a pilot expect on minesweeping duty? At times the flying is so rhythmically droning and dull that you've got to shake yourself to stay awake. But fliers are still able to find plenty of challenges. Just watch Paul Widish, a young Navy lieutenant doing his first tour in minesweeping with the fliers in HM-15, as he describes his early attempts at mastering Tornatore's juggling act.

As the lean, narrow-eyed Midwesterner swivels back and forth in his chair, you can see he's not only wrestling with imaginary helicopter controls, he's wrestling with himself. Hanging half out of the chair, held in only by his seat's invisible shoulder straps, it's obvious he envies the little motions, the gentle taps and pulls, that more experienced

Budget cuts have made it hard for pilots to build tow time. Right: HM-14 pilots Shay Beeth and Ed Fassnacht and crew members Mike Smith, Carl Carswell, and Steve Spirrison (left to right, respectively).

pilots use to keep their big minesweeping machines on a tight track. "Got it…got it…got it," he says over and over as he mentally replays a torrent of control corrections to recover from ever larger course deviations. In minesweeping, it seems, getting just a little out of line can ruin your whole day.

DOG IS MY COPILOT

by Allan Janus

Among the million-plus photographs in the National Air and Space Museum's archives are a surprising number of images of dogs. If mankind has long dreamed of flight, the dream of taking along the family dog apparently came along shortly afterwards. Although the Wright brothers didn't bring a canine pal with them to Kitty Hawk, intrepid dogs were soon taking to the skies. During the world wars, an aviator without a loyal mascot thought himself frightfully ill-equipped. And will we ever really accept spaceflight as routine until NASA retrofits the shuttle with a dog door? Here are a few of our favorite Sky Dogs (along with one Cloud Cat).

Ah, for the good old days when you could light up on the plane and enjoy a smoke with the wind whistling through your fur! Pilot Shakir Jerwan does the work while Monoplane puffs contentedly at the Moisant School of Aviation, Mineola, New York, July 31, 1912.

Topper, an Army Air Forces mascot who built up his frequent flier miles ferrying bombers to England, takes five on the prop of a Piper L-4.

No one who ever witnessed a mass para-dog assault is likely to forget the experience: the sky filled with blossoms of silk while the sound of excited barking slowly descends. As the four-legged troopers hit the drop zone, they quickly chew off their rawhide-flavored parachute shrouds and, in an overwhelming show of force, liberate every enemy fire hydrant in sight. Then again, perhaps this photo shows the Air Force's "Operation Para Dog" of 1948, which parachuted sled dogs onto crash scenes to aid in rescues.

The Messerschmitt Bf 109 may have been one of the outstanding fighter planes of the second world war, but it had a serious drawback as far as the squadron mascot was concerned. Except in emergencies, the canopy couldn't be opened in flight, so how could the faithful *Staffelhund* stick his head out the window and let his tongue loll in the breeze? Apparently breaking the bad news to the pup is a pilot of the second group of *Jagdgeschwader* (Fighter Squadron) 51.

Back in the first decade of flight, a unique breed of dog appeared: the Spotted Cockpit Bull Terrier. It was a good thing too; a little warm dog could be darned useful in those drafty open crates. Below, French pilot Edmund Poillot appears *avec ami* in a Voisin biplane at the Farman Aviation School in Mourmelon, circa 1913; above, aviation pioneer Glenn Curtiss and his dog go through the preflight checklist in one of his pushers, circa 1912.

"All right, raise your right paw and repeat after me..." Perhaps it was about time that not just pilots but their mascots be licensed—bad dogs need not apply. Actually the photo captures a more remarkable moment: the beginning (or end; documentation is unfortunately conflicting) of a 23-day round-the-world flight in the summer of 1928. Checking the time is A. Shorry, secretary of the National Aeronautic Association (left); John Henry Mears holds the relaxed and confident Tail Wind, a Sealyham Terrier, next to pilot Charles B. D. Collyer.

Mears, Collyer, and Tail Wind made the flight in a Fairchild FC-2W with folding wings (which traveled with them by boat for the ocean crossings), stopping only to refuel, grab a few hours of sleep, and meet the inevitable dignitaries.

Pictures taken during the journey show an affable Tail Wind meeting and greeting, while Mears and Collyer just look tired. When Collyer commented, after the trio's return, that Tail Wind "did have the better of the journey in that he had plenty of sleep and an occasional dog biscuit," it seemed to be with a touch of envy.

The dog peers intently from the side gunner's position. Looking beyond the defensive bomber box high above Germany, he picks out an intruder. "Woof, woof, woof!" he barks into his throat mike. "What is it, boy? Bandit at 3 o'clock? Good boy!" And so, perhaps, has Mister, mascot of Staff Sergeant Harold E. Rogers, earned his kibble after another mission. Mister had flown five missions when this 1943 Army Air Forces photo was taken.

Boots, the mascot of the Military Police at Randolph Field, Texas, doesn't appear to be suffering from a lack of self-esteem in this World War II-era photograph. Put on a pair of goggles, slip into the old parachute harness, and you're top dog! What a shame there's no way to attach dog tags to a silk scarf.

Cats were aviation pioneers as well, and here's a particularly heroic one. Kiddo, the first feline to attempt to cross the Atlantic by airship, was the pet of the crew of the *America*. Kiddo initially had a rough time of it, howling piteously during takeoff on October 15, 1910. But he quickly recovered, as navigator J. Murray Simon recounted: "You must never cross the Atlantic in an airship without a cat. We have found our cat more useful to us than any barometer. He is sitting on the sail of the lifeboat now as I write, washing his face in the sun, a pleasant picture of feline content. This cat has always indicated trouble well ahead. Two or three times when we thought we were 'in' he gave most decided indications that he knew we would shortly be getting it in the neck."

They got it in the neck after 71 and a half hours in the air—breaking all records for manned flight in a powered aircraft—and dropped into the ocean 475 miles east of Maryland. Crew and cat were rescued by the steamer *Trent* and returned to New York City for a hero's welcome: For a time Kiddo was displayed at Gimbel's department store on plush cushions in a gilded cage. He appears here, ready for anything, with *America*'s engineer, Melvin Vaniman.

THE LONELINESS OF THE LONG-DURATION ASTRONAUT

Science can explain what long space missions do to the human body. Less tangible is what they can do to the mind.

by Henry S.F. Cooper Jr.

SOVFOTO (LEFT); NASA (SKYLAB)

During his 211 days on Salyut 7, cosmonaut Valentin Lebedev struggled with anxiety and boredom. Until last year, the record for Americans in space was only 84 days, set aboard Skylab (left).

The United States is embarking on a series of long missions in space, yet we have done surprisingly little research into the psychological problems that might occur on them. These problems, which include anxiety, emotional hypersensitivity, insomnia, irritability, and depression, do not show up on two-week space shuttle flights but can be serious enough on longer missions to impede and even end them.

NASA pioneered long-term missions with Skylab in 1973 and 1974 and almost immediately ran into trouble. Crew members Gerald Carr, Edward Gibson, and William Pogue began the third Skylab mission with a fast-paced schedule that it had taken the preceding crew eight weeks to build up to. As a result they constantly felt behind in their work and became demoralized. On their 45th day in space the crew went on a sit-down strike, refusing to perform scheduled tasks. Mission control in Houston later acknowledged that the work schedule had not given the astronauts adequate time to adapt to their environment, but disregarding orders was, to say the least, an unusual response for astronauts. After a few adjustments, the crew settled down and eventually completed an 84-day mission. The reaction at the agency: problem solved.

To the Russians, 84 days is a mere drop in the samovar. More than 40 cosmonauts have lived in space for months at a time; many more than once, and several for a year or more. Valery Polyakov, the current record holder, returned to Earth in March 1995 having spent 438 days aboard the Mir space station. Even with this formidable experience the Russians too have had difficulties with workload and cosmonaut response. But the Russians freely acknowledge the part that psychological stresses play in causing these difficulties. In fact, the director of medical services at the Russian Institute of Biomedical Problems recently named psychological issues the "most difficult" of the challenges cosmonauts face on long missions.

The Russians have identified three phases in a cosmonaut's attempt to adapt to space. The first lasts up to two months and is dominated by adjustments to the new and busy environment. This is followed by a phase of increasing fatigue and decreasing motivation, which the Russians call asthenia. What once seemed exciting becomes boring and repetitious. Next comes a lengthy period during which the asthenia, which can include depression and anxiety, worsens. Tastes in music and food change. The

While cosmonauts are adapting to space, psychologists have discovered, they are two and a half times more likely to make mistakes.

spacefarers are unusually upset by loud noises or unexpected information. This is the period when crew members get testy with one another and with the ground crew. The litany of ills seems drastic, but it should be regarded as a universe of possibilities. Not all cosmonauts experience all of the symptoms; some cosmonauts don't experience many of them, and in no case has the psychological damage been permanent, though there is an adjustment period after returning to Earth.

All these findings bear a significant correlation with studies of men and women on long missions to remote places on Earth. Isolation and sensory deprivation are the common denominators, whether the mission is in the Arctic wastes or the realm of the deep. In one Antarctic station, anxiety episodes increased from three during the first four months to 19 during the last four. On two cruises of Polaris submarines, five percent of the crew experienced incidents of anxiety, depression, or psychosis. In a study of personnel who wintered over in the Antarctic in 1969, 85 percent reported periods of significant depression, 65 percent had periods of anger or hostility, 60 percent suffered from sleep disturbance, and 53 percent had impaired cognition.

Team members, friendly at home, face off against one another when separated from traditional social supports. On the International Biomedical Expedition to Antarctica organized in 1977, a 12-man adventure lasting 72 days, bickering became such a problem that psychologists accompanying the expedition had to intervene with stress management therapy. Three men withdrew from some of the psychological experiments. Antarctic literature is full of stories about teammates who stopped talking to one another or who fought—one celebrated tale concerns a cook with a meat cleaver facing off against an engineer brandishing a fire ax.

While space travel cannot match some of these dramas, it is in the same ballpark. There are many reports of tension among crew members in space. There have been episodes in orbit in which one crew member did not speak to another for several days; there are even rumors of fist fights—one reportedly over a chess game. Tensions frequently spill over to mission control, as they did in the Skylab strike. One Russian crew aboard a Salyut space station reportedly got so angry at mission control that the cosmonauts shut down communications for 24 hours.

According to other Russian reports, at least three missions have been aborted for reasons that were in part psychological. In one case, the Soyuz 21 mission to the Salyut 5 space station in 1976, the crew was brought home early after the cosmonauts complained fiercely of an acrid odor in the space station's environmental control system. No cause was ever found, nor did other crews smell it; conceivably it was a hallucination. Coincidentally, the crew had not been getting along. In the case of the Soyuz T-14 mission to Salyut 7 in 1985, the crew was brought home after 65 days when Vladimir Vasyutin complained that he had a prostate infection and couldn't urinate. Later, doctors felt that the problem was partly psychological. Vasyutin had been getting behind in his work, and he was also under pressure because he had been passed over for a flight several times before. Alexander Laveikin was brought back early from the Soyuz TM-2 mission to Mir in 1987 because he complained of a cardiac irregularity. According to flight surgeons, there had been no sign of it before flight, nor could they find any sign of it in flight or afterwards. The cosmonaut had been under stress—he had made a couple of potentially serious errors. Later, he complained of the arrhythmia. He also had not been getting along with his partner, Yuri Romanenko.

A good deal of this information is undocumented and anecdotal; it makes for good stories, but not necessarily for great psychology. U.S. psychologists sometimes fault their Russian colleagues for being stronger on anecdotes than on verifiable experiments or statistics. "Rumor, rumor, rumor," one Western psychologist said to me recently, shaking his head, when I asked him about these tales.

The Russian approach to the psychology of spaceflight focuses on three areas: cosmonaut and crew selection, crew training, and psychological support during the mission. The process starts with testing. Candidates for the Russian space program are given a test similar to the Minnesota Multiphase Personality Inventory, which NASA gives astronaut candidates. It is a test of some 500 true-false questions intended to uncover psychopathology—that is, whether a candidate is prone to conditions such as depression, anxiety, or schizophrenia. Candidates also take such clinical tests as the Rorschach, in which they are asked to interpret a variety of ink blots—also a measure of psychopathology and stability. One of the testers, Rostaslav Bogadeshevsky, a large, jovial man in his 60s, told me that one test he favors is a graphic test in which he asks a candidate to draw a man using a variety of Jungian symbols, including a circle (which stands for sense), a triangle (intuition), a square (logic), and an L-shape (ethics). He also asks the candidate to place these symbols at random in a grid. Through various interpretive methods, he can determine how the candidate sees himself and the extent to which his conscious is in tune with his unconscious. "If the two are not in tune, it may be evidence that he is in the wrong business," Bogadeshevsky said. "It may be that in becoming a cosmonaut he is trying to resolve other problems—a situation that could lead to neurosis."

At the end of the first stage of the selection process and at the beginning of training, the candidate is put into a soundproof chamber for a week or more. First the psychologists keep him awake for three days, doing a variety of psychological and medical experiments. "A person who has weak motivation will not survive this!" Bogadeshevsky said. "We find out what is inside him—his achievement and motivation will be seen. We see how he avoids failures—we look for his weak points so we can

ROGER RESSMEYER © CORBIS

U.S.-designed station modules resemble the living quarters of submarines.

correct them. Americans don't do anything like this!"

And it is difficult to imagine astronauts putting up with it if we tried. It may be that such tests are possible in Russia because the cosmonaut is far more receptive to psychology than his American counterpart. Though no one would fault a cosmonaut's "stuff," it is a different sort from the so-called "right" variety. Patricia Santy, a psychologist at the Johnson Space Center from 1984 until 1991 and author of the recently published book *Choosing the Right Stuff*, plotted on a graph cosmonaut and astronaut scores on the Minnesota Multiphase Personality Inventory. The graph showed that astronauts tend to be more aggressive to the testers, whereas cosmonauts are more accepting, possibly because (unlike astronauts) they see psychologists as helpful. They also are more introverted than the astronauts, perhaps a sign that they are more in touch with their feelings. Taken another way, the graph shows the broad cultural differences between members of two societies that have had very little exchange over the past half-century. Russians have appreciated their emotional side at least since Dostoyevsky and are therefore more likely to pay attention to psychological matters.

After he is released from the isolation chamber, the candidate is given a vigorous workout in a centrifuge to simulate the gravity forces of launch and landing, and he is whirled in a chair to test his vestibular system, which controls his sense of balance. Although these are basically medical tests, the psychologists are watching. "All the time we are estimating his ability, watching how he proceeds with his inner reserves," Bogadeshevsky said.

The Russians believe that these "inner reserves" can, with practice, be developed. Irina Solovyova, a trim, sharp-eyed, intrepid-looking woman, is the training center's chief instructor in parachute jumping (a course required of cosmonauts but not given to astronauts). Significantly, she is not only a cosmonaut but also a psychologist. "We try to test and enhance qualities we feel will be important to cosmonauts in space, such as emotional stability or the ability to isolate oneself emotionally from a situation," she said. "In free fall, the cosmonaut is entirely on his own. It is a model of an emergency condition. It helps develop his reaction to stress—something that is very difficult to simulate on the ground. The richer the cosmonaut's experience, the better. The deeper his image of the forthcoming flight, the easier it will be for him to cope with it."

Assignment to a crew concludes the process of cosmonaut selection. First the cosmonauts being considered are asked to rate one another's interpersonal skills, and from this peer review the psychologists try to identify people

ANN HAWTHORNE

who will get along. Crew assignments are made at this point, usually by the head of the Gagarin Space Center, Pyotr Klimuk (a cosmonaut), and one of the deputies of Energiya, the organization that builds spacecraft and supplies most of the engineer cosmonauts. Despite their input, Russian space psychologists are not certain of the extent to which they actually affect selection.

After selection, a psychologist or a doctor is assigned to the crew. There are not enough psychologists to go around, so a doctor often fills this role, but he is backed up by the psychological staff. Either way, he is clearly more than just another form of mission support. Oleg Zdhanov, the head psychologist at the Gagarin Center, told me that from the start, he is the crew's lawyer and babysitter, representing their interests to management and, during flight, to mission control.

After the crew is formed, the psychologists and others continue to monitor the members' compatibility; changes can always be made. They give the crew another battery of Rorschach tests, this time collectively. The psychologists watch to see how well the crew can agree on a common interpretation of the ink blots; at this point, one crew member able to sell his ideas to the others may emerge as the leader. They may do a certain amount of role playing, sometimes in simulators, with cosmonauts acting out what they would do in various situations that might occur in space.

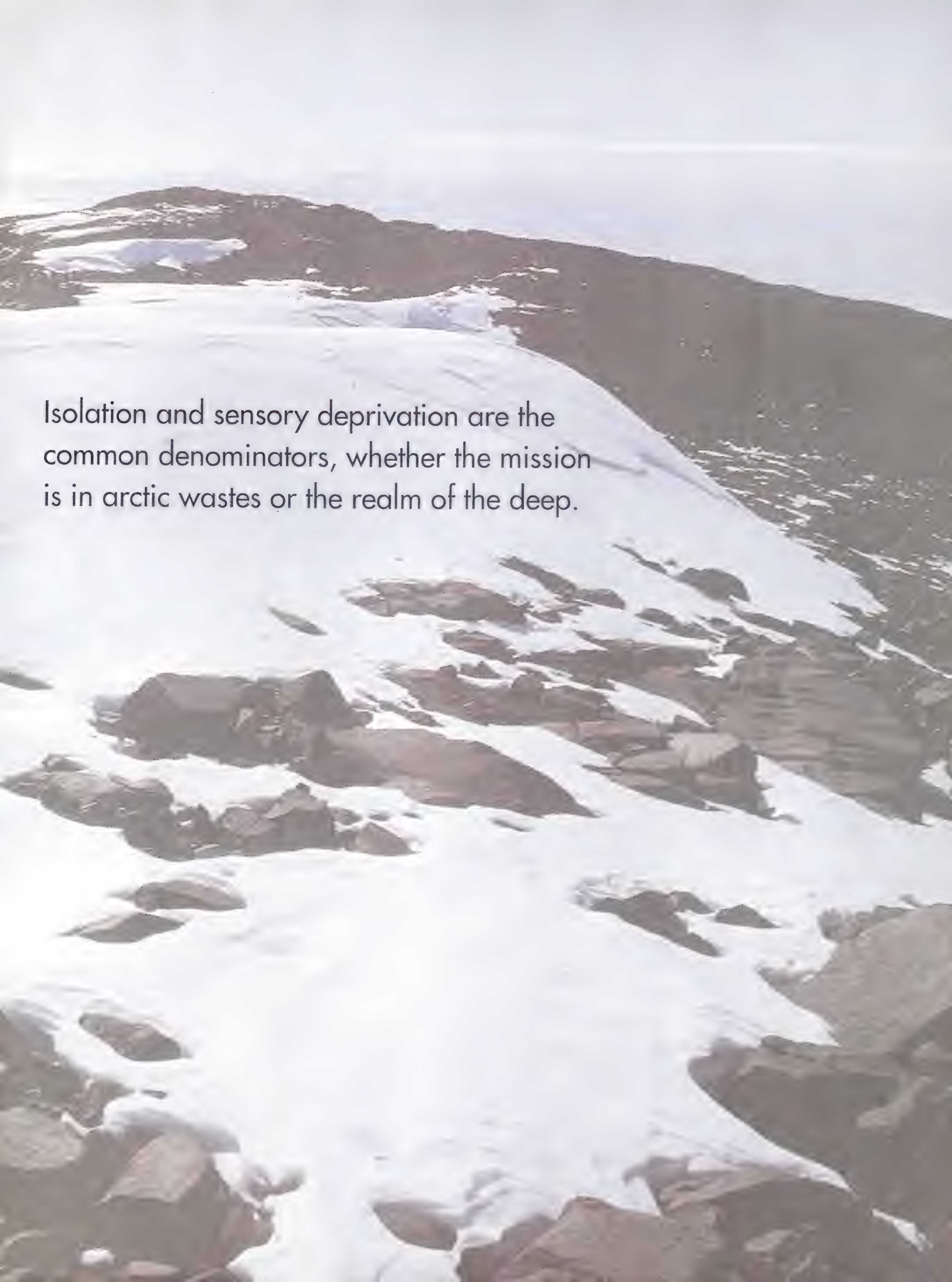
Their compatibility is also tested by how well they can match words together. Bogadeshevsky applies his graphic tests once more; by their use of Jungian symbols, he believes he can tell how well the members of a crew complement one another. Their pulse is taken while they are performing tasks jointly; Russian psychologists believe that if people are in harmony, their pulses will synchronize. They are sent to remote places for survival training, or on automobile trips. The purpose of these excursions is to see not just if they come back alive, but if they come back as friends.

The cosmonauts are also given what the psychologists call "homeostatic" tests. In one, each member of the crew is put into his own shower stall. All water temperature adjustments are linked so that they work as one, and the cosmonauts, who cannot communicate, are told to arrive at a consensual temperature. An alternative to the shower is a wobbly platform that two or three crew members have to stand on and jointly balance with hand controllers. Despite all the testing and advice on how to get along, incompatible crews do sneak by. One was yanked from a mission a week before launch.

Although U.S. psychologists admire their Russian counterparts' emphasis on human nature in spaceflight, they are not convinced that these tests are useful. The shower, the synchronized heartbeats, and some of the other tests, they feel, have not been properly validated. It could be that Russian psychologists are more subjective, or intuitive, than American psychologists with their love of statistics and validations, just as cosmonauts are more subjective than the more pragmatic astronauts, and perhaps just as the Gagarin Center is a shaggier place than its neatly cropped Houston counterpart.

After launch, the crew psychologist from the Gagarin Center is augmented by a new team of psychologists from the Institute of Biomedical Problems in Moscow, who specialize in flight support. Their work starts right away, while the crew is adapting to space.

One U.S. astronaut, F. Story Musgrave, a physician who has flown several times on the shuttle, told me that adaptation to space is at least as much a psychological matter as a physical one. "It is a change in consciousness, in the way you view the world," Musgrave said. "It is essentially a psychological experience, at the level of the brain." In addition, many of the physical things that happen—the redistribution of body fluids, the atrophy of unused muscle, bone, and cardiovascular capabilities, and the quiescence of the vestibular system—require a psychological adjustment. One Russian psy-



Isolation and sensory deprivation are the common denominators, whether the mission is in arctic wastes or the realm of the deep.

chologist at the Biomedical Institute, V.I. Myasnikov, believes that the shift of blood and other body fluids toward the brain may disrupt brain tissue and exhaust the nervous system, and hence may be a somatic cause for some of the symptoms of asthenia.

While the cosmonauts are adapting, the institute psychologists have to lean on the flight controllers at the mission control center, in Kaliningrad outside Moscow, to keep the cosmonauts' schedule light. During this period, the psychologists have discovered, the cosmonauts are two and a half times more likely to make mistakes, so they should not be given any complex or dangerous tasks.

At first, the cosmonauts are buoyed by the excitement of the strange new environment, but after a couple of weeks the excitement wears off and the troubles start. Far and away the most vivid picture of a cosmonaut's emotional deterioration appears in the diary of Valentin Lebedev, who spent 211 days aboard the Salyut 7 space station. He was launched on May 11, 1982, and by May 21 he was already beginning to quarrel with crewmate Anatoly Berezovoy, who complained that he was forever catching Lebedev's stuff floating around the Salyut cabin. By May 23 Lebedev was beginning to suffer from insomnia. "If you don't sleep enough, you're worn out, and your face is swollen," he wrote. "Your mood isn't so great, either. What am I going to do? It's only been ten days." By June 4, his relations with mission control had turned chilly. On June 15 he recorded an anxiety attack: "I could hardly get up. Everything hurts. Yesterday, I worried too much. My stomach had spasms. My heart was pounding in my chest like a hammer…I felt drained all day."

The psychologists have a variety of remedies to counteract the debilitating effects of asthenia. Basically, they try to keep the cosmonauts' schedules reasonable and regular, and they try to keep life aboard a space station as Earth-like and as integrated with their home life as possible. On one occasion Lebedev's crew doctor sensed that he was depressed and interrupted the evening period of communication with him, telling him to hold on a minute. Lebedev wrote in his diary: "Suddenly I heard a very familiar Ukrainian melody. I couldn't understand where it came from. Finally it dawned on me. It was my son playing the piano. It was so wonderful and unexpected that tears ran from my eyes."


SOVFOTO

ROGER RESSMEYER © CORBIS

The doctor's treatment made use of two antidotes contained in every Russian psychologist's black bag: family and surprises. Cosmonauts can phone home anytime they want. Psychologists arrange weekly two-way television visits with families, friends, or celebrities who come to the control center. And aboard the supply ships, which usually follow within a month of a crew's arrival, they send magazines, newspapers, mail, and special surprises: books, films, music tapes, snack food, and plants. (Before each mission, the psychologists ask the crew to fill out a long list of favorites.)

When I visited the Institute of Biomedical Problems, a rundown building in an out-of-the-way corner of Moscow, I talked with several psychologists, in particular two who were closely involved with mission support, Olga Kozerenko and Alexander Sled. Kozerenko is a motherly woman who seems to fill the role of babushka to the cosmonauts. "Experience shows that they are very sensitive to the attention of people on the ground," she told me. "They are like spoiled children! They have a great many things up there—a library of 200 books, perhaps 50 movies—but they always want something else. They are homesick. They have to be reminded

NASA JOHNSON SPACE CENTER

Clockwise from upper left: Sergei Krikalev and Alexander Volkov escape for a moment the tedium aboard Mir, but Yuri Romanenko, ensnared by health-monitoring equipment, gives a truer picture of daily life in space. U.S. astronaut Shannon Lucid is living aboard Mir until August. Her latest request to the supply ship: more M & M's. Despite the physical discomfort space travelers must endure, astronaut F. Story Musgrave says the experience is "essentially psychological."

over and over again that you are thinking of them. They don't say this, but we sense it. And they get upset when they don't think they are getting enough attention. Once a crew called down and said, 'What's happening down there? We don't think we are getting enough psychological support!' They had opened a supply ship and not found the tapes they were expecting. A little later they found them and they were delighted. They felt some kind of special love from the ground."

As with babysitters everywhere, the psychologists are the target of considerable abuse. Sometimes the cosmonauts complain about the music that is sent to them. "We don't like this music! We don't like heavy metal!" one crew groused. It turned out that they preferred music sent up for a previous crew, and they were jealous.

Tastes change. According to Alexander Sled, a clever-looking psychologist with black hair and beard who works closely with Kozerenko, early on the crew might express a preference for classical music and later choose popular songs. The psychologists have sent videotapes of conventional Earth scenes, such as forests or seacoasts, on the theory that it would ease the ache in their hearts for their home planet, but the cosmonauts don't seem to spend much time watching them. They're boring. Generally cosmonauts prefer comedies or adventures. One tape that is always popular is *Star Wars*.

The psychologists are sometimes able to cheer a cosmonaut by sending something even he didn't know he wanted. Vladimir Titov, who spent a year aboard Mir in 1988, told me of the profound joy he felt in looking just inside the hatch of a supply ship and finding a bunch of fresh flowers. "We put them in the place of honor, where we eat," he said. Alexander Laveikin, who had experienced the cardiac problems on Mir in 1987, opened one supply ship to find his guitar floating toward him. (The guitar is still aboard Mir, where it continues to ward off asthenia.)

The cosmonauts' sense of taste loses its edge over time (a side effect of congestion from the shift of body fluids into their heads); consequently, psychologists send them foods with strong flavors. In 1992 I spent a long evening at the home of Gennadi Strekalov, who in 1990 had voyaged for four months on Mir with Gennadi Manakov; most recently, he was U.S. astronaut Norman Thagard's crewmate aboard Mir. An apple tree was dimly visible in his back yard. Its apples—particularly small and red—had a pungent taste he loved. He was also fond of a spicy Russian bacon his wife prepared. "Each week I'd call her on the phone and tell her what I wanted to eat," he said. The psychologists made sure he got it.

I chewed on the bacon and the apples while watching home movies that Strekalov had taken aboard Mir. He also brought out some brandy. He said his wife had sent him some for his birthday, the only verified report of alcohol aboard the space station.

Strekalov's trip seemed idyllic (although I heard later that he and Manakov had not always hit it off). Psychologists encourage cosmonauts to pursue some creative activity aboard Mir, such as writing or painting; making a videotape film was a sort of creative therapy for Strekalov, whose dark hair frames a handsome, rather gentle, face. Although he and Manakov conducted some 250 experiments, time sometimes dragged, and—like people in isolation anywhere—they welcomed almost anything that helped the time pass. "Look," he said while we watched the movie. "See the cockroach! It came up on the supply ship. We had a choice—to exterminate him or to make him a member of the crew. We made him the third member of the crew. We called him Grisha." Grisha kept popping up throughout the film, which conveyed the monotony of space very well—the cosmonauts seemed reduced to amusing themselves in the manner of long-term prisoners. One cosmonaut, Yuri Romanenko, took up songwriting in space, to the delight of the psychologists; they were dismayed, however,

SOVFOTO

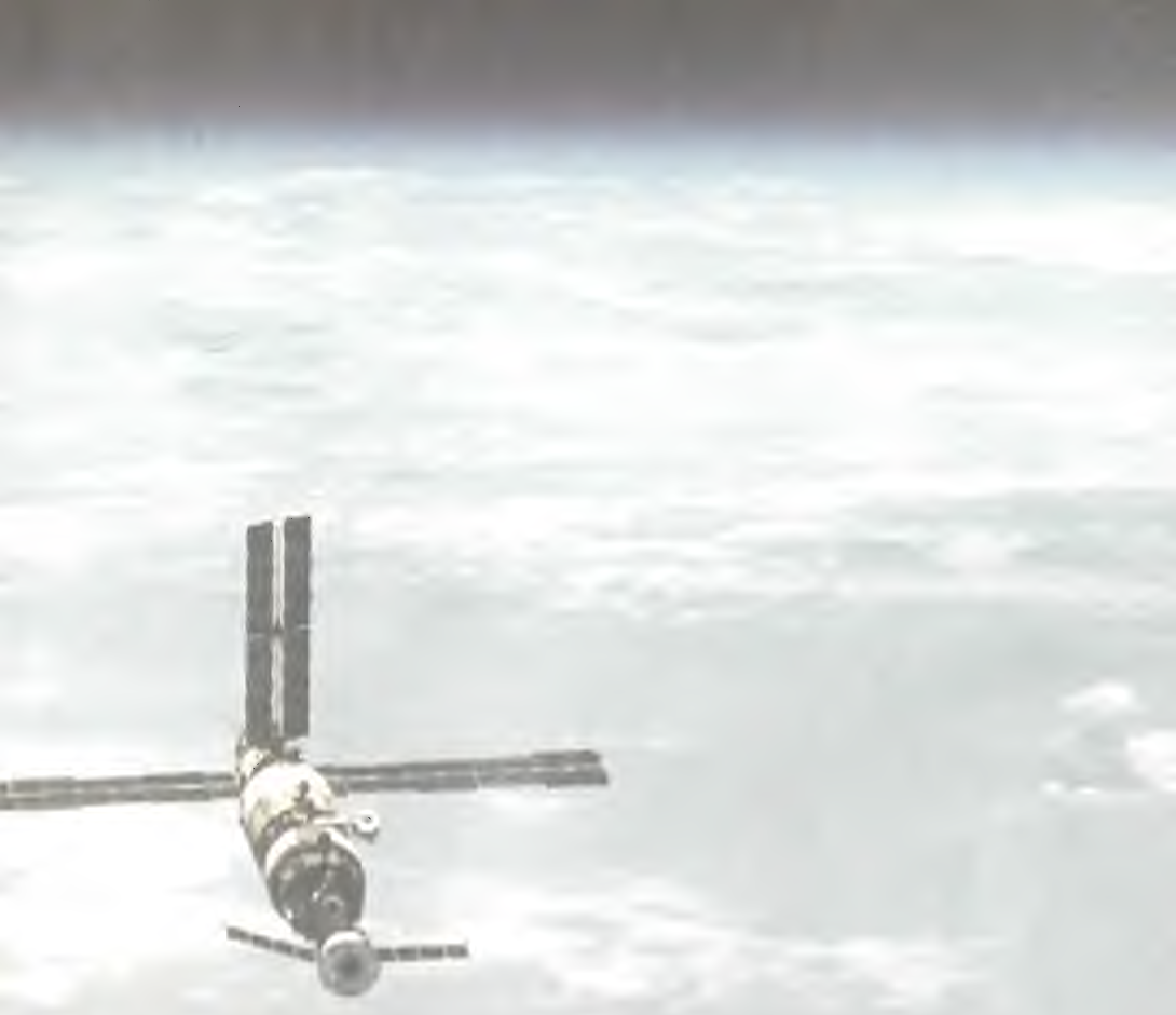
The Russians feel the Americans have a long way to go; the Americans feel the Russians' techniques are more art than science.

when many of the songs likened Mir to the gulag.

One way the psychologists keep tabs on the cosmonauts' mental state is by monitoring their conversations. Much of this is done in a small control room in a cinder block building at the back of the Institute of Biomedical Problems, which I visited with Sled, who spends a good deal of time there. A recent crew of cosmonauts, Yuri Gidzenko, Sergei Avdeev, and Thomas Reiter (of the European Space Agency), were being monitored by Nina Zapriska, a lively woman who said she was keeping an eye, or an ear, on the crew's psycholinguistic status—that is, listening for any semantic changes in crew conversation. She was particularly watchful for the cosmonauts' perception of the passage of time. "Time flows quickly or slowly depending on your psychological state," she said. "I listen for such statements as 'Time flies' or 'It seems like a long while that we've been up here.' " If time was dragging, she would watch for asthenia. She assured me that at the moment the crew was in good shape, psycholinguistically speaking.

If the psychologists sense a crisis, they will first bring in members of the family. They might then bring in a seasoned cosmonaut whom they know the crew admires to talk about his own ordeals in space and how he endured them. One thing the psychologists do not do in a crisis is intervene directly. There is no couch aboard Mir, and they don't try group dynamics therapy. "We do not think psychologists should talk to them," Sled said. "We view them as healthy men who are temporarily under stress. We feel that we must show there is psychological support. We make them see that they have problems and they have to reconsider things."

On astronaut John Blaha's mission to Mir this summer, NASA will begin its first systematic collection of psychological data on long-duration missions by recording crew interactions with one another and with mission control. Psychologists at the Johnson Space Center see the need to collect and analyze their own data to understand psychological issues. For certain problems, according to NASA psychologist Al Holland, they have obtained no useful data from the Russians. The effect of long



periods without sexual activity, for example, is, says Holland, "certainly something to pay attention to."

Though the Russian and American psychologists are good friends and spend a lot of time at each other's space centers or communicating with each other on the telephone or by e-mail, they are wary of each other's experience and techniques. The Russians feel the Americans have a long way to go; the Americans feel the Russians' techniques are more art than science. To me, much of the Russian work seemed like good old-fashioned common sense. Because of the differences in experience and method, Zdhanov and other Russian psychologists want to set up cross-cultural training.

Holland and his colleagues in Houston debriefed NASA's first astronaut to live on Mir, Norman Thagard, after his 115-day mission in order to improve their support of astronauts while they're in space. As a result, astronaut Shannon Lucid, Thagard's successor , is getting regular broadcasts of U.S. news and frequent teleconferences with her family.

Thagard had told reporters who asked about the rigors of long-duration missions, "My impression is the psychological aspects probably loom largest." Interestingly, Thagard himself experienced none of the symptoms of asthenia. He told me that part of his mission was to put himself "in the position of someone who'd be up there for a year" and that he had made his comments based on that.

"Somehow, that's come to be interpreted as problems I was having," Thagard said. "At my worst—mid-point—I always knew I was going home next month, and in that situation you can't be too upset at anything that's going on. In fact I was interested in the articles that said I was sad, lonely, and homesick, and I can honestly say I was never any of those things."

It is reasonable to think that U.S. astronauts who stay in space longer than Thagard's 115 days will also have Thagard's "no big deal" attitude. This is what we have come to expect from our astronauts. Still, we are about to go where the Russians have already gone, and it would be wise to listen to the more traveled cosmonauts and their psychologists.

For more about long-duration spaceflight, browse the Web at www.airspacemag.com/supp/JJ96/supp1.html

The more things change, the more things look like the New Dodge.
So look for the next new Dodge, coming soon to your Dodge dealer.

Dodge Viper GTS. Eight liters, ten cylinders and an estimated 450 hp.
Of course it's the Official Pace Car of the 1996 Indianapolis 500.

Gen•
engine

The New Dodge Caravan. We thought of everything.
No wonder it's just as original as the original.

Dodge Stratus. We questioned everything.
Which will explain why this car is so full of answers.

netic
eering.

Dodge Intrepid. Its cab-forward design changed everything. Including the very architecture of the American sedan.

Dodge Ram Pickup. The rules have changed. From its safety features, to its comfortable ride, to its powerful line of Magnum® engines.

Dodge Neon. We took cab-forward and gave it a whole new personality. And the longer you look at it, the brighter it gets.

Dodge Avenger. It's the kind of car that could get by on looks alone. We engineered it so it would never have to.

The New Dodge
A DIVISION OF THE CHRYSLER CORPORATION

Want more information? Call us at 1-800-4-A-DODGE or visit our Web site at http://www.4adodge.com

In the Grip of a Whirlwind

Why moving air plus mountains adds up to one very nasty hazard for pilots.

by Carl A. Posey

Illustrations by John Kachik/Wood, Ronsaville, and Harlin, Inc.

Pilots from such places as Boulder and Colorado Springs—towns along the strip of foothills between Interstate 25 and the Continental Divide—know they're home when an invisible hand closes around the airplane and gives it a good shake. It is nature's way of telling them they have returned to the surf zone on the lee side of the Rockies, a kind of aeronautical Kona Coast where atmospheric waves several miles high and perhaps a hundred miles long break across the high passes and 14,000-foot peaks of the divide, then spill over the slopes beyond.

Along the ground, these breaking waves are felt as great gusts of wind, or the pulsing, warm breath of a chinook, and are mainly a hazard to roofs, power lines, and trees. But in the air they are the unseen fists that come knocking on the wings and fuselage, that give an airplane the unnerving—occasionally catastrophic—shake. They are tolerable only because we can't see them. If we could, we would be like drifting protozoans looking up, aghast, as a great wall of water explodes on our beach and flows toward us in a chaos of maelstroms great and small.

On such days—usually they occur in winter, when the north-south flow is strongest—one is conscious of something wild and crazy in the atmosphere. Generally, one can take off into it, fly in its uncomfortable surf, make reasonable landings in its gale, and fib to friends that it wasn't so bad after all. Seasoned mountain pilots find nothing especially terrible about the winds around a breaking mountain wave—they seem to take the sudden sinkers, the unexpected boosts, in stride. Indeed, glider pilots have for decades used lee-wave winds as a ladder—often a rough one—to greater altitude. Still, there is the sense of some dangerous whimsy latent in this confusion of currents; in flight as in life, wild and crazy things are the first to let you down.

Drawing a diagram of a mountain wave is simplicity itself: Place a triangle of mountain in a stream of air. The air is cammed upward on the windward side of the triangle and descends on the lee side. In the lee of the triangle's apex, a standing wave is fringed by a lens-shaped cloud. As the air rises and cools, the cloud condenses into visibility; it vanishes as the sinking air is heated by compression.

The danger lurks beneath this standing wave, in a circulation of air—a rotor—that marks the mountain wave crest. Along the ground, under the air flowing directly over the triangle, small-

er rotors could be drawn, signifying the shears and eddies created as the air whips along terrain. The larger rotary circulation is associated with a gigantic gravity wave—the vast breaker foaming invisibly across the divide. Its vertical motion through the atmosphere is caused by gravity: as the air is forced up over a mountain it becomes denser—heavier—than the air around it, and gravity works to bring it down on the lee side. The smaller rotors are produced by the friction and drag near the surface. Typically, in the Rockies such gravity waves originate with the jet stream blowing along the tropopause from the Alaskan Low two thousand miles to the northwest.

Terry Clark, who creates numerical simulations for the National Center for Atmospheric Research in Boulder, finds the mountain wave phenomena easily sketched but, in the fine details at least, not so easily reproduced in a computer model. Gravity waves are like ocean waves, of course, and this pounding wave of air breaks over the Front Range like surf—to a degree. But at the level of detail needed to see it fully, it is more complex than anything performed by water. The bearded Canadian-born scientist has been working on the problem off and on for the last 20 years. "When I began, it wasn't understood what started these events," he says. Now his work has more to do with gustiness, with detail, with the peculiarly random behavior of the rotors, which can be oriented vertically or horizontally or anywhere in between and which are marked by increases in wind velocity that theory still does not quite explain.

But the mountain wave does more than dominate low-level weather along the downwind side of high terrain—it also influences atmospheric layers all the way through the stratosphere. The waves deposit energy where they break; however, like ocean waves, they do not break along their entire front at the same time—they break here and there, feeding momentum into the surf zone at varying intervals. Since the wave is not fully broken, it continues to pump energy up through the atmosphere, ultimately shaping the temperature and wind fields of the mesosphere, 50 or so miles up. At low levels, Clark says, "when you get these rotors forming and breaking up, like surf, you get a non-linear cascade of scales of energy. You get cross-stream instabilities, anomaly transfer."

Well, talking to a numerical modeler about what he models is something like chatting with Star Trek's Commander Data about reconfiguring the meson screens—the conversation never quite becomes untechnical. But Clark is very clear about what he wants to know, and how rotors express themselves near the ground. "We're trying to get to how strong these rotors can be," he says. "From our limited experience and modeling, we haven't seen any leveling off in the magnitude of vorticity. I suspect one could get close to the shear values of a tornado." As for anomaly transfers, he is talking about rotors that are generated several miles away, then spin wobbly like tops down the slope for perhaps 10 miles.

In 1968 a Fairchild F-27B encountered a mountain wave that ripped off the right outer wing and other pieces of airframe.

PAUL J. NEIMAN

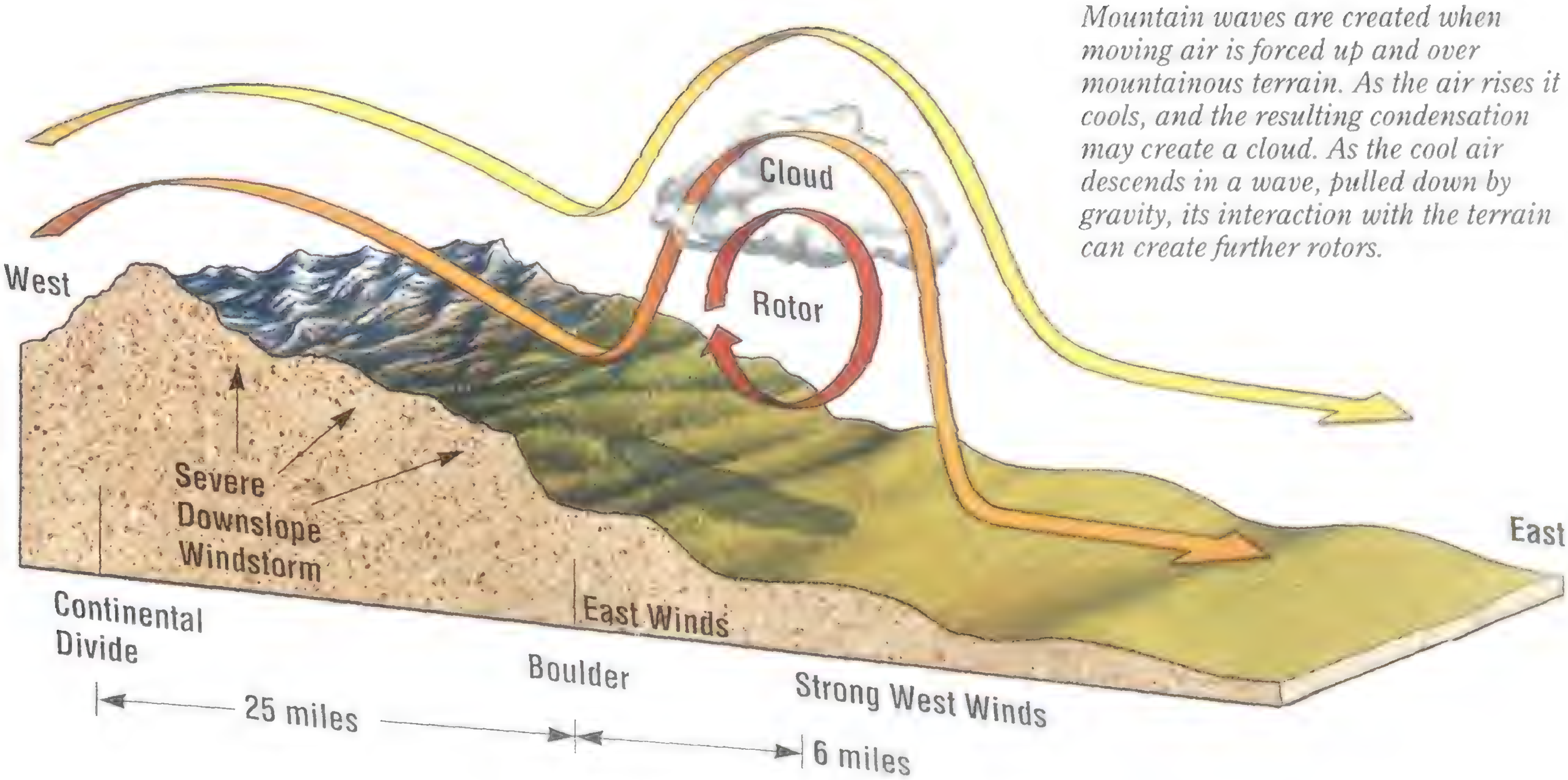
Lenticular Cloud

No one knows if United Airlines flight 585 encountered these atmospheric demons at Colorado Springs on March 3, 1991. Certainly it was one of those days that buzz with insane eddies and turbulent flows along the Front Range. The wind was from the north-northwest and filled with invisible discontinuities. In Colorado Springs, a city about a thousand feet higher than mile-high Denver to the north, winds of a mere 10 knots were measured a thousand feet above the ground. Other sensors found 39-knot winds at that level, and 142-knot winds at 14,900 feet, about 800 feet higher than the crest of Pikes Peak, northwest of the city.

All morning, pilots had been telling one another about the wave beginning to break along the Rockies, with some reporting wind shear from plus 40 to minus 40 knots. "Sounds adventurous," responded United 585's first officer when the tower relayed a report from a 737 that found considerable wind shear on a final approach to runway 35—minus 15 knots at 500 feet, plus 15 at 400, plus 20 at 150. United 585 had already added 20 knots to the 737's target speed for final approach to provide a cushion in the event that the aircraft's airspeed dropped between wind gusts.

The captain was just beginning the initial descent. It would be his first landing at Colorado Springs as pilot in command, and it was a milk run—23 minutes from Denver's Stapleton Airport with two on the flight deck, three in the cabin, and 20 passengers. Nothing about the flight seemed to tax the considerable abilities of the pilot and copilot—he had almost 10,000 hours' flying time, she had almost 4,000, and each had spent about a work-year flying the 737. The turbulence had kicked them around some south of Denver, but it was a moderate chop.

Level at about 8,000 feet, the captain set the flaps and put the wheels down,



Mountain waves are created when moving air is forced up and over mountainous terrain. As the air rises it cools, and the resulting condensation may create a cloud. As the cool air descends in a wave, pulled down by gravity, its interaction with the terrain can create further rotors.

then turned from a southerly heading toward the northeast, into the stiff wind burbling over and around Pikes Peak, Mt. Rosa, and Cheyenne Mountain—three great boulders poking up into the stream. The 737 descended toward the point where its course would intercept the extended centerline of runway 35, still some five miles to the north. The pilot reduced the power, and then, as the descent accelerated, added power and made a 20-degree bank to the right, lining up with the runway. Seconds later, he pushed the power up some more.

"We're at a thousand feet," the first officer called.

Lined up with the runway and momentarily level, United 585 suddenly—inexplicably—resumed its bank to the right, but this time kept rolling until it was inverted. "Oh God," said the first officer. The captain called for reduced flaps. United 585 continued its improvised Split S, heading almost straight down, inverted. Then the nose passed through the vertical and came up a few degrees, as if something—the captain's hand on the wheel, the 737's aerodynamic preference for flight—was bringing the airplane back toward control. But a thousand feet is nowhere near enough room for a Split S in a 737. United 585 crashed about four miles short of runway 35, killing everyone aboard.

The National Transportation Safety Board, whose report describes those sad final moments, was unable to say what brought the 737 to the point of no return. It was possible that the aircraft's rudder controls had developed a subtle problem, although simulator reenactments could not reproduce the crash. Some detect the hand of mountain wave winds in the accident. Certainly there was plenty of wind buffeting the surface that day—90-mph gusts two miles east of the crash site, gusts of 50 to 70 mph almost a mile closer, "terrible shear" and "a very hard hit" reported by a Super King Air south of the city, a 70- to 80-mph whirlwind along the ground five miles north of the airport.

But there are many who do not see enough wind to produce the crash. Boeing ran simulations in which winds of increasing viciousness were added incrementally, but did not succeed in flipping the airplane inverted; most could be handled with aileron control. But high-velocity currents in a horizontally oriented rotor, combined with horizontal movement by the rotor, produced forces that could have made that 737 very hard—perhaps impossible—to fly.

Curiously, there is no consensus on whether mountain-wave phenomena are a significant aviation hazard, although they are manifestly able to rip aircraft apart. Some cases in point: A B-52 had about three-fourths of its vertical stabilizer bitten off by 95-mph gusts at 14,300 feet over southern Colorado in 1964. In March 1966 a BOAC 707 blew apart as it flew by Mount Fujiyama. "It was in smooth air," says Terry Clark, "then hit something like a wall. Broke the plane in pieces. On board, a Japanese passenger was taking moving pictures. In the last minute the camera skipped two frames, and it appeared that there were rugs flying through the air." That chilling footage provided the only clue to what happened to the plane, for there were no black boxes then.

Up at Pedro Bay, Alaska, in December 1968, a Fairchild F-27B encountered mountain wave currents that ripped off the right outer wing, empennage, part of the left wing, and other pieces of airframe. There have been a number of others. But the most telling, according to Clark, might have been the one that happened in December 1992, when a cargo DC-8 lost an engine and part of a wingtip southwest of Denver. "The wave was breaking up around 10 kilometers," recalls Clark—about 33,000 feet. But in that event, the invisible demons of the surf zone did not go unseen. A Doppler lidar operated by the National Oceanic and Atmospheric Administration recorded the wild move-

ment of air as the wave crashed across the Rockies. It was one of the rare instances in which scientists have been able to see the clear atmosphere in the act of savaging an airplane.

Doppler lidars—optical ranging systems that use laser, not radio, beams to track motion—are easily blinded by atmospheric moisture but are sharp observers of clear air. Actually, they sense the movement not of air but of microscopic particles suspended in it. In doing that, the lidar has begun to reveal just how much evil whimsy hides in the mountain wave.

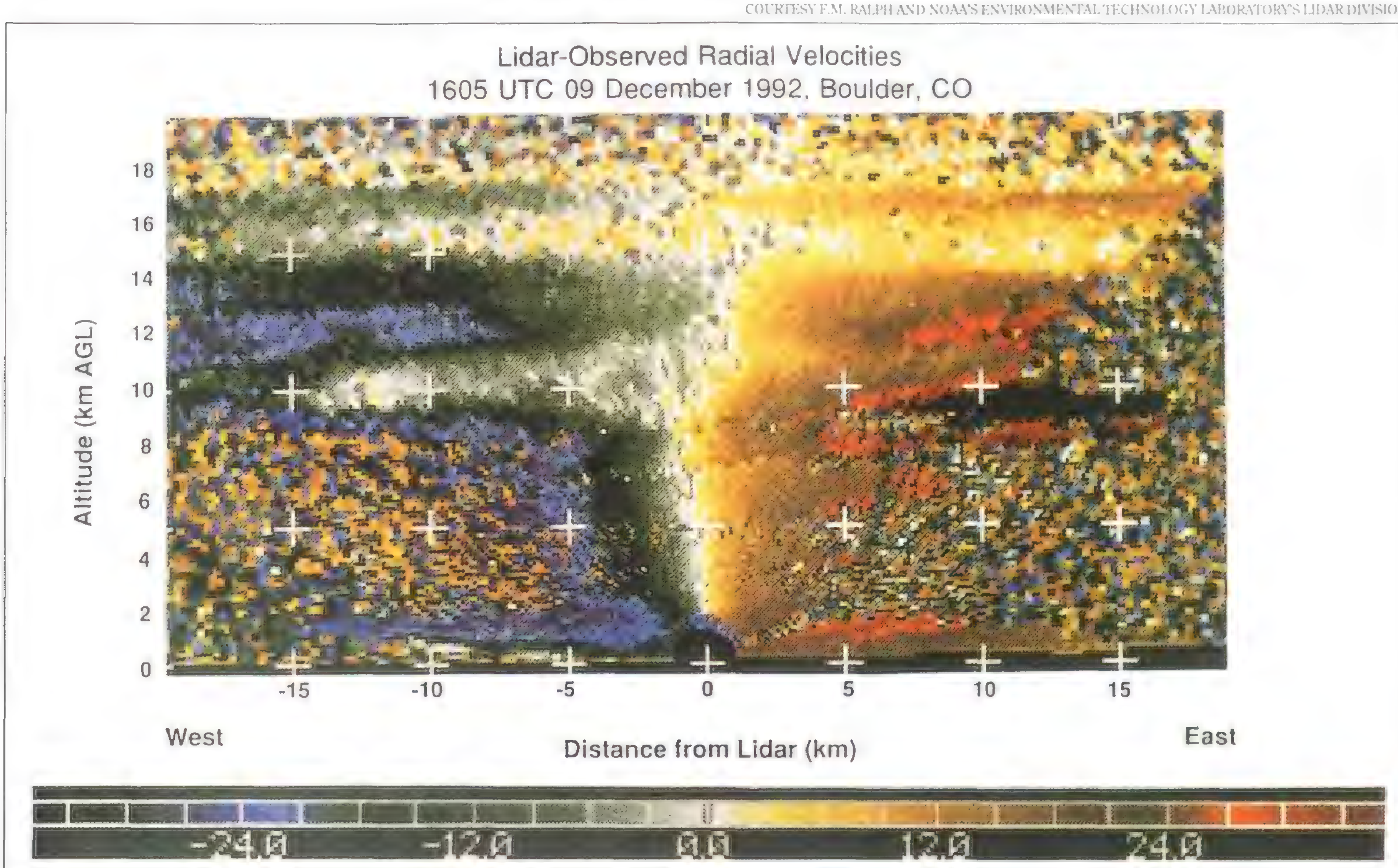
Clark and others are putting such knowledge to work theoretically, hoping to learn how to mesh the observed with its atmospheric context, and how to predict these very chaotic, squirrelish events. But he is also working on an eminently practical application. Under a $15 million contract from Hong Kong's Royal Observatory, NCAR is applying such knowledge to the design of a meteorological warning system for the new airport planned there. Unlike the present terminus, whose runways jut into the bay from Kowloon on a narrow oblong of fill, the new airport will be sited east of the metropolis, on the island of Lan Tau—in the lee of the 3,000-foot Lan Tau peak, which can produce the same kind of downwind whirlpools and currents found downstream of Pikes Peak and other high terrain.

Clark's particular interest is in the giant breaking gravity wave. NOAA's Alfred Bedard has appropriated the smaller, mechanically induced rotors that go tumbling out from under the big wave. Bedard is a tall yet pixieish man with a high, round forehead and a crest of red hair, and he has made a specialty of the low-frequency register of infrasonics, the frequencies favored by thunderstorms, continent-size gravity waves, and avalanches. After noticing a correlation between mountain waves and low-frequency acoustic waves of about 0.1 Hertz, Bedard became involved in Project Aeolus, which used an array of remote sensors sprinkled around Boulder to scrutinize the footprints of downslope wind storms. In 1984 the Federal Aviation Administration approached him with a problem: how could vertical spacing of aircraft at altitude be reduced safely?

A pilot determines his altitude based on atmospheric pressure, which, at high altitudes, may or may not match his real height above sea level. In mountainous areas, the upward propagation of mountain waves will disturb levels of constant pressure and possibly create complications for aircraft, which was what worried the FAA. "We interrogated aircraft—Where do you think you are? What do you think your altitude is?" Bedard says. "We knew where they were supposed to be, but where they actually were...we found some significant differences." The researchers also discovered intimations that mountain waves were a hazard that had not yet received much attention.

Of course, everyone has always understood that the mountains are a very different, more demanding environment than the flatlands. Every year more

COURTESY F.M. RALPH AND NOAA'S ENVIRONMENTAL TECHNOLOGY LABORATORY'S LIDAR DIVISION



Doppler lidar uses lasers to observe the movement of particles suspended within the air—and hence the air itself. For this image the lidar's laser scanned from due east, through the vertical, to due west over a period of a minute. The mountain wave it detected is breaking at an altitude of 10 kilometers, 12 kilometers west of the lidar.

airplanes are lost, sometimes to the surprising thinness of the air on takeoff, sometimes to the sinks and shears and vortices of mountain wave winds. A General Accounting Office report issued in December 1993 found that from 1983 through 1992, the general aviation accident rate was almost 40 percent higher for 11 mountainous western states than for the other 39 states combined, and 155 percent higher at selected mountain airports than at comparable airports in other, flatter, regions.

As a first step in pilot education, Bedard and his Boulder colleagues are working with the FAA to develop some training aids—in particular, a cloud atlas for mountain flying. To this end, he has been collecting donated photographs of the various cloud types associated with mountain waves (and would be happy to see more, by the way).

Looking at these images, one is again struck by their suggestion of evil mischief. There are the familiar lenticular, or lens-shaped, clouds, which follow the standing wave well above the ridge line, and there are wave clouds with the stylized, regular scallops. Some take the shapes of great white turbans and hover like pristine motherships in the lee of the mountains. Some look downright angry and devouring, a witch's streaming wig of cloud drawn out in strands by the winds. Yet all are symptoms of things we cannot see. It is not the cloud that will gobble up an airplane, but the invisible winds swirling in every direction closer to the ground—winds in which the only clouds are shards of cumuli.

Shears and whirlwinds also occur at higher altitudes, and Bedard, after years of listening to the infrasonic growls of weather, has begun reading what these winds write in the high troposphere—in contrails. He sees turbulence in corkscrewed contrails, and in contrails shaped like whips. As a passenger, Bedard says, he has looked out the window and "seen this tremendous thing, and we just flew right into it." Sometimes the tremendous thing feels like a wall.

Beyond pilot training, Bedard hopes to see a multi-year observational program start within a year or two, so that lidars can begin systematically monitoring mountain wave rotors and shears and document the details of this significant aviation hazard. To show where scientists are at the moment, he cites the paradigm of the microburst. Years ago, the University of Chicago's Tetsuya Theodore Fujita inferred the existence of microbursts—vertical exhalations from building thunderclouds that produce aircraft-threatening wind shears near the ground—from a study of aircraft responses and wind damage patterns (see "The Might of the Microburst," Aug./Sep. 1986). But it was not until the arrival of Doppler radar in the 1970s and 1980s that Fujita's insight was confirmed.

It's not the cloud that will gobble up the airplane, but the invisible winds swirling in every direction closer to the ground.


PAUL J. NEIMAN

Lee Wave Clouds

Bedard is also exploring rotors with the fluid modeling facilities at the University of Colorado's aerospace engineering department. "I took a class for somebody," he explains, "and ended up building up a fluid-modeling possibility to address one part of the lee wave problem"—the interaction of the lower level of moving air with terrain.

The facility is the usual jumble of handmade equipment, its tanks and rotating stands, hoses, and ducts giving it the messy, haywire look of all such laboratories. Here Bedard is using a small water tunnel to simulate the rotors that spin across the ground under a lee wave—to show with ink plumes in moving water how, for example, a small, powerful, eastward-moving rotor might have rolled out of the Front Range on March 3, 1991.

Again, not everyone believes a rotor caused the Colorado Springs accident. Joachim Kuettner, the man who discovered mountain waves nearly 60 years ago, is one who does not. "They interrogated me on the crash," the Breslau (now Wroclaw, Poland) native says in German-accented English. "I couldn't see a rotor in it. If it happened, the rotor would have been very low and far from the mountains." Now 85, Kuettner continues his work at NCAR and helps develop the giant international experiments fielded by the World Meteorological Organization's member nations. His interest in mountain wave phenomena mainly centers on the way the waves propagate tens of miles into the atmosphere.

Back in the earlier days of his long career, Kuettner was both a world-class glider pilot and a pioneering student of mountain winds, which still excite his piloting instincts. "In 1937 my doctoral thesis was the discovery of the mountain wave," he says. "I had worked with clouds or gravity waves over clouds. Then, one time in Silesia, the sailplane would keep climbing, we couldn't tell why. The question was: Why would you fly higher on the downwind side of a mountain than on the upwind side, when the air streaming over the mountain is descending on the lee side? Did the up-

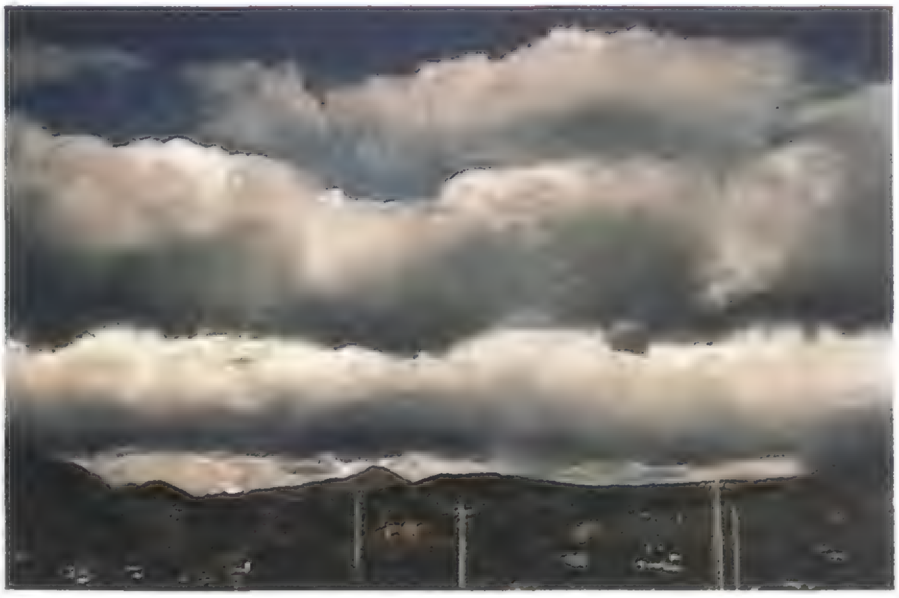
ward motion on the windward side continue upward? Or was there a vortex on the lee side that caused you to climb?

"One day when a huge wave cloud was in evidence I decided to go up in a small open glider to investigate it," Kuettner says. "I was towed up into the wave and then started soaring, keeping in front of the wave cloud in order to fly visually. The glider's altimeter scale went up to 3,000 meters, and above that level I had no idea of my altitude, but I kept on climbing because I was curious to know how high the updraft went. After some time I suddenly realized that I was seeing two suns, that I could not feel my feet anymore and that my fingernails had turned blue. The air temperature was –45 degrees C and of course I was suffering from lack of oxygen. To make my escape I turned to fly alongside the wave cloud and eventually landed at a Polish village a long way from my starting point." The barograph on the glider said the wave had carried him to about 7,000 meters—23,000 feet—an unofficial world record. His discovery of mountain waves was read by scientists everywhere except in the United States, where relatively few read German.

While Kuettner does not see the hand of lee wave winds in the Colorado Springs crash, he knows better than most how strong the rotor's winds can be. Newly arrived in the United States after World War II, Kuettner became field director of the Sierra Wave Project, in which scientists backed up by sailplanes and powered aircraft probed mountain waves along California's Sierra Nevada in the 1950s. The wave action did not disappoint. Updrafts over Bishop were so strong that a pilot in a P-38 Lightning soared to 30,000 feet—with his propellers feathered. Kuettner made two world records: 11,500 meters (37,700 feet) for two-seat gliders and 13,000 meters (42,650 feet) for single-seaters.

"Ever since the mountain wave has been discovered," Kuettner wrote in a 1956 paper based on the Sierra Wave Project, "observers and pilots have been aware of the fact that the smooth lee wave has a strange and rough companion, the 'rotor flow.' The majority of the lee wave theories consider this disagreeable fellow as an insignificant byproduct of the lee wave or ignore him altogether. In contrast, pilots caught in the grip of the rotor have acquired great respect for his manners and tend to consider rather the smooth lee wave as a good-natured companion of the rude rotor. Like Cerberus at the gate of Hades the rotor guards the gates to the smooth wave and a flying intruder venturing unsuspectingly into his range is first clubbed by an unbelievable turbulence, then dumped in a severe downdraft and eventually will be happy to beat a hasty retreat."

"His parachute opened while his feet were still caught in the cockpit. It could have ripped him in two."



PAUL J. NEIMAN

Lee Wave Clouds

April 25, 1955: Glider pilot Larry Edgar encounters severe rotors. Edgar survives; his glider does not.

In his office in Boulder, Colorado, Kuettner tells the rotor tale to end all rotor tales. The critical flight was made on April 25, 1955. Kuettner and Larry Edgar were patrolling a mountain wave in their gliders. "We were flying in two different sailplanes at thirty-five, forty thousand feet in the wave, which followed the shape of the mountain range," Kuettner says. Normally, he points out, the wave follows the divide. "Then the wave straightened out into one line, sitting far back. We were several hours there and came back together. I had a hard time to stay against the wind. I descended to 17,000 feet, higher than the mountain range. The turbulence increased in suddenly horizontal gusts—it increased so much that my airspeed went too high. I put the nose up, almost vertical, and still too much airspeed. So I made a high-speed stall and fell down, recovering after a thousand feet or so. Then there was another, stronger gust. I made it down. That was the front side of the rotor.

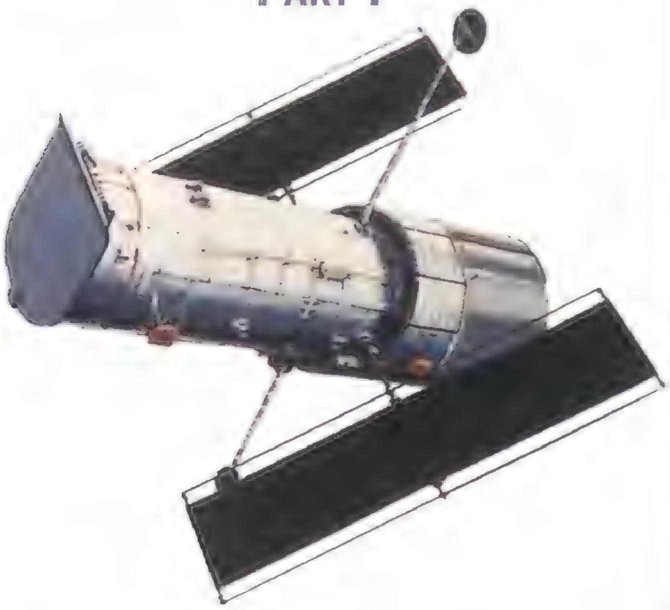
"All I could tell Larry Edgar in the other glider...I warned him. There is such incredible turbulence, you have to be careful.

"He got into the same thing, five miles farther south. He was so close to the cloud that cloud puffs formed in front of him, and in clouds he couldn't make the maneuver. A tremendous buildup of speed, such acceleration there, especially negative.... The wings came off and he was thrown through the cockpit. His parachute opened while his feet were still caught in the cockpit. It could have ripped him in two. He kicked off his shoes and the parachute carried him into the cloud. Down. Then back and up again. He was in shock when we found him." The wrecked glider bore the marks of an astonishing confrontation. "His sailplane must have gotten 16 Gs," says Kuettner.

One may wonder, hearing this scientist's mild reference to 16-G accelerations, what else one needs to know about the crazy winds that blow along the lee slopes of mountain ranges. In that simple double digit, the aviation hazard seems pretty well defined.

For video footage of mountain wave effects, browse the Web at www.airspacemag.com/supp/JJ96/supp2.html

THE VIEW FROM THE HUBBLE
PART I



Pluto's Portrait

Even the mighty Hubble has to strain to see this tiny, distant planet.

by Tony Reichhardt

On a hot summer day in 1994, six years after he first asked for it, Pluto finally arrived on Alan Stern's desk. The planet—digital images of it, to be exact—came by express mail, on two cassette tapes. The meager handful of photons captured in those images had traveled nearly three billion miles through space before bouncing off the main mirror of the Hubble Space Telescope, which is orbiting 330 miles above Earth.

From there the photons converged at the Hubble's focal plane, striking a detector in the European-built Faint Object Camera. The resulting electrical signal was then relayed from the telescope to a NASA satellite, down to an antenna in New Mexico, over to NASA's Goddard Space Flight Center in Maryland, and then to the Space Telescope Science Institute (STScI) in Baltimore, where the data was calibrated, cleaned up, and shipped off to Stern's office at the Southwest Research Institute in San Antonio. The whole journey, from Plu-

PAUL DiMARE

Artists can use their imaginations to visualize Pluto and its moon Charon, but astronomers have found that even with the Hubble Space Telescope, the distant planet remains largely a mystery.

to to Texas, took just a few days.

Almost two years later, when Stern and his collaborator, Marc Buie, finally released the images at a NASA press conference in Washington, D.C., all the major television networks carried the news on their evening broadcasts. The photos—the most detailed look yet at a planet discovered in 1930—made the *New York Times*, *USA Today*, and dozens of other newspapers and magazines around the world.

The success of the press conference was in some measure due to Stern's skill at explaining science. Eminently quote-worthy, he spoke of "knock-your-socks-off" images, "a tantalizing first look," and the need to send a spacecraft to Pluto to take even better pictures.

But the cautious scientist in him knew that as good—even historic—as these pictures were, they represented, to him and his colleagues anyway, only one small step on the path to fully exploring Pluto. "What usually comes out of Hubble or any other telescope," he had mused back in 1994, before he ever saw the Pluto pictures, "are little advances, this whole edifice that you build up, brick by brick."

In 1988, when he first proposed using the world's most powerful telescope to study the solar system's last uncharted planet, Alan Stern was still in graduate school at the University of Colorado. Today, at the age of 38, he is one of the country's top planetary astronomers. The Pluto observation was his fourth turn on the Hubble; previously, he had looked at Jupiter's aurora and Neptune's largest moon, Triton (twice). But it's Pluto that really holds his interest. At the time of the Hubble observation, he was deeply involved in planning a NASA spacecraft mission then called the Pluto Fast Fly-By. Until such a project materializes (now renamed the Pluto Express, the concept is still awaiting funding), the Hubble telescope will provide our best look. And that appealed to the explorer in Stern.

He began the mission by assembling a team of experts. Laurence Trafton of the University of Texas helped with the detailed planning that might make the difference between a failed observation and a winner. Marc Buie of the Lowell Observatory in Flagstaff, Arizona, who joined the team later, was also a Pluto aficionado. When the planet and its moon Charon had gone through a rare series of "mutual events" in the late 1980s, repeatedly eclipsing each other as seen from Earth, it was Buie who had done the most sophisticated analysis of the changing pattern of shadows cast by the eclipses. Careful study of this data told him which parts of the planet's surface had a higher albedo, or brightness.

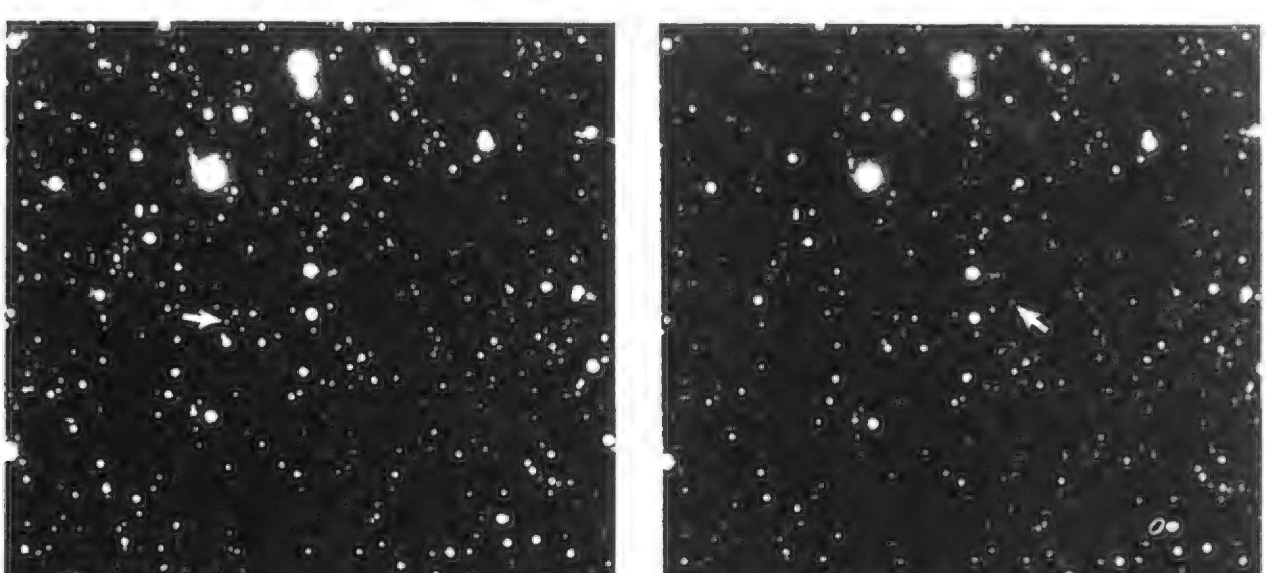
In fact, Pluto had already been crudely mapped with ground-based telescopes before the Hubble came on the scene. Buie and others had used the mutual events and more than 30 years of data on the planet's variable brightness (which is caused by different viewing

angles from Earth, as well as the planet's 6.4-day rotation period) to infer where the light and dark areas were on its surface. These techniques had a lot of built-in uncertainty, however, and the results depended on how the numbers were crunched. The two best maps both showed a bright south polar cap, for example, but disagreed on whether the north had a similar feature.

The Hubble observation, if the team could pull it off, would replace shaky inference with direct photographic evidence, and would help determine which indirect mapping technique had been the most accurate. But even with the Hubble, it wouldn't be easy. Pluto is so small and distant that ground-based instruments can't clearly separate it from Charon, much less show any detail. The planet is only about 1/10 of an arc-second, or 1/36,000 of a degree across, about the limit of Hubble's resolution. That makes viewing details on Pluto akin to reading the print on a golf ball from 33 miles away, or counting the spots on a soccer ball from 400 miles, or distinguishing between two headlights...well, you get the idea.

While working at Lowell Observatory in Flagstaff, Arizona, Clyde Tombaugh (pictured in his New Mexico back yard in 1980) discovered Pluto on February 18, 1930. Pluto (marked by arrows below) revealed itself by its motion across the sky, evident in photographs Tombaugh had taken six days apart in late January.

DALE WITTNER



LOWELL OBSERVATORY PHOTOGRAPH

Buie would be invaluable not only for his Pluto expertise but for his familiarity with the arcana of Hubble data processing. He had worked at the STScI and had helped to write the first programs for tracking planets with Hubble, and he knew how to get the most out of a meager amount of space telescope data. The Pluto pictures, in all their glory, would have only about eight picture elements (pixels) across the whole disk of the planet. Because each pixel represented more than 170 miles, the scientists knew they would have to wring every last bit of information from each.

Other teams had already used the Hubble to observe Pluto, including a German group that photographed the planet after the telescope was repaired in 1993. But Stern hoped—somewhat audaciously—to extract enough information to map its surface. First of all, by taking photographs at four different longitudes as Pluto slowly turned on its axis over the course of two six-day rotations, he would gain almost full global coverage. The proposal also called for recording images in two types of electromagnetic radiation: visible light, at a wavelength of 410 nanometers, and ultraviolet light, at a wavelength of 280 nanometers. The shorter-wavelength, higher-frequency ultraviolet radiation emitted by Pluto would provide an image with finer resolution and more information about the surface. (To understand the relationship between wavelength and resolution, think of a pair of calipers: A pair with a finer scale of markings can measure more detail than a pair with coarser markings.) Measuring in the UV was a clever way to get twice the resolution from the telescope's Faint Object Camera (FOC), which would better differentiate variations in Pluto's icy surface. And by comparing the UV and visible-light maps, Stern and Buie would have a powerful tool for modeling the composition of the surface.

It was this proposal that the STScI accepted back in 1988, shortly before the telescope was launched. Because of the subsequent problem with the Hubble's mirror, though, all observations requiring high resolution—the Pluto pictures among them—had to be put off. Worse yet, after the telescope was repaired, anyone who wanted to use it had to enter into a whole new competition for the time. To improve his chances of being accepted, Stern dropped his original plan to use both the telescope's Wide Field Planetary Camera and the FOC, settling for just the FOC. His proposal was selected again, and in the summer of 1994, Observation #5330, "High Resolution Mapping of Pluto's Albedo Distribution," finally came off as planned.

The telescope took the pictures on four days in late June and early July—a set of ultraviolet and visible observations on each day, three exposures for each observation, for a total of 24 pictures. STScI then did a standard computerized "pipeline processing" (which

includes factoring out the handful of known dead spots in Hubble's field of view), placed the data in the permanent archive, and shipped off copies to Stern. One of the tapes got lost in the mail (its images having traveled across the solar system!), so the STScI had to send another copy.

Once the image files were loaded onto computers at Southwest Research, the work could begin in earnest. The raw data looked promising—it was obvious that some squares in the checkerboard-like images were bright and some were dark. But it was way too early to start jumping to conclusions about whether these were real features.

Stern and Brian Flynn, a postdoctoral scientist working with him at Southwest Research, first did a few simple reality checks, like making sure the same features showed up in different exposures taken on the same day, or checking to see if a spot that appeared on one day had moved on the next day's image, when the planet had rotated a quarter-turn. If it did, Stern and Flynn would have more confidence that they were seeing something real.

Still, the best anyone could hope for at this resolution was to see gross provinces of light and dark, which was precisely the point of the experiment. As Buie would explain two years later at the NASA press conference, "You can't do geology in these images," meaning you could forget about distinguishing mountain ranges from smooth plains.

The albedo variations did tell you something, though. The light areas are thought to be regions where fresh nitrogen "snow" has fallen out of the planet's thin atmosphere. The darker areas are what passes for bare ground on Pluto—methane ice darkened by the effects of the scant sunlight that reaches the planet. Even though these pictures ultimately revealed Pluto to be the most "contrasty" object in the solar system (with the exception of Earth), the variation in brightness only amounts to the difference between clean Colorado snow and dirty Boston snow.

Before nailing down where these provinces were on a map, though, there was still a lot of hard image processing ahead. Stern compares it to "twiddling knobs"—adjusting the picture on a TV set, but with a dozen or more variables

JAY KOELZER

Alan Stern has achieved one of his goals: photographing Pluto with the world's most powerful telescope.

to tune exactly right. With each step lurked the prospect of making a mistake. Stern still remembers with a "sinking feeling" the time he published a result that turned out to be dead wrong. He had made an observation using a brand-new telescope, and the processing software the observatory sent along with his data had a bug in it. That experience taught him that you can't be too cautious. "Take it from a guy who's been wrong," he says. "You have to be wrong once or twice to appreciate that."

For an object larger than Pluto, the data processing would have been fairly straightforward, and it wouldn't have mattered much if a few pixels here and there were out of alignment. But in this case, a few pixels were all they had, and the computer processing was everything. "The data have so much subtlety to them," says Stern, "that you really have to get in there and have the bits almost talking to you to really be sure of what you're seeing."

The first task was to sharpen each of the images as much as possible, using a computerized process known as deconvolution. But it didn't go very well. The technique involves applying a mathematical formula characterizing a particular instrument's known degree of blurring (every telescope has some) to reconstruct what a perfect image would have looked like. Deconvolution, in effect, corrals the blurred light from an object back into a nice, tight circle.

It fell to Buie, the person with the most experience massaging Hubble data, to do much of this nitty-gritty work. But after applying three different types of deconvolution and thousands of computer "iterations," the images weren't coming out exactly right. In some cases they even got worse. Features that had shown up clearly in the raw images would disappear. Or, if the computer happened to sharpen the image's noise instead of real light from Pluto, some spurious feature would pop up out of nowhere. The problem with deconvolution, particularly when you are working with only eight pixels, is that "you don't know when to quit," says Buie. "You can just keep iterating and iterat-

DAN COOGAN

Working with a meager amount of data, Lowell Observatory's Marc Buie spent countless hours generating computer-processed images of Pluto.

ing and sharpening and sharpening."

So they decided to drop deconvolution and go to Plan B. First Buie used a computer to generate an artificial image exactly the size and shape of the ones of Pluto, with a grid overlaying its surface just like the grid of pixels on the Hubble image. Then he tuned the brightness of each pixel in the artificial image to roughly match what appeared in the real images. Next came deliberate blurring—to duplicate the blurring effects of Hubble. The final step was to carefully align, or register, the two pictures (fake and real) and subtract out the difference, leaving—*voilà*—an idealized but noise-free version of what the telescope actually saw.

Buie repeated this process for each of the 24 images. It was time- and computer-intensive, rewarding in its own way but frustrating too. Every little thing had to be taken into account. At one point he found that even a slight jitter in the telescope at the time the exposures were taken—only 1/10,000 of a degree or so—had degraded some of the images.

Even more frustrating was never being able to work on the problem for more than a short stretch of time. Buie had to fit the Pluto work into an already hectic schedule: observatory visits, meetings, proposal writing, and all the other hassles of the working scientist.

Stern was even busier. In fact, he was in the middle of one of the most frantic years of his life. Shortly after receiving the Pluto data, he and his wife had a third child, and the family moved from San Antonio back to Colorado. During one stretch in the spring of 1995, which was not at all atypical, Stern traveled to the McDonald Observatory in Texas to observe the moon's atmosphere, made a quick pit stop at home, then flew to NASA's Marshall Space Flight Center in Alabama to work on an experiment that was flying on the space shuttle. After another guest appearance at home, it was off to Toulouse, France, for a scientific meeting on ices in the solar system, then home for one night, then into the field with a sounding rocket experiment for two and a half weeks, back home briefly, then to California for another meeting. The day after he returned home from nearly six weeks of continuous travel, his taxes were due.

"If I could shut out the world and go to Antarctica, we would do this whole project in two months," he lamented.

It wasn't as if they had forever, either. By STScI rules, any scientist who uses the Hubble gets exclusive access to the data for exactly one year from the day the observation is made. After that, anyone can go into the archives and help himself to the original tapes. At first Stern felt some pressure—what could be worse than another scientist scooping you with your own data before you could publish the results? As the months wore on, though, and it became obvious that the team wouldn't be able to publish within a year, it started to seem less of a worry. For one thing, it was a damn difficult task. If anyone else thought he could do it better or faster and still get it right, he was welcome to try.

By the time of the annual Lunar and Planetary Science Conference in Houston in March 1995, Stern trusted the pictures enough to begin presenting them to other scientists. In his talk he said that the images showed roughly a dozen albedo regions on Pluto's surface. One intriguing linear feature might even be a crater ray (later he felt less confident about that interpretation and dropped it). It was always "dangerous to overinterpret" the pictures, announced Stern, who underplayed how far along he and Buie had taken the image processing. This was a "progress report" only.

For months, NASA's press people had been bugging him to release the pictures. Not until they're ready, was his standard reply, and NASA always backed off. But magazines were starting to ask too: When are we going to see the pictures?

In the end, it was an external event—an educational project in which schoolchildren got to make their own Hubble observations of Pluto—that forced the team to wrap up the first phase of their work. The original plan had been to publish the Pluto images first as a short paper in a scientific journal, then do the

NASA press conference, then follow with a more comprehensive paper comparing the new photos to the old maps. But to avoid having the schoolchildren steal their thunder by releasing Pluto images first, Stern and Buie would have to go public, *then* publish.

It wasn't a matter of resenting the schoolkids (Buie was in fact supervising the observation for them). But it did force them to hurry up the remaining work to meet the deadline. For one thing, the images—each of which covered only part of Pluto's surface—still had to be "unwrapped" and laid down in strips to create a flat map showing where the light and dark regions were.

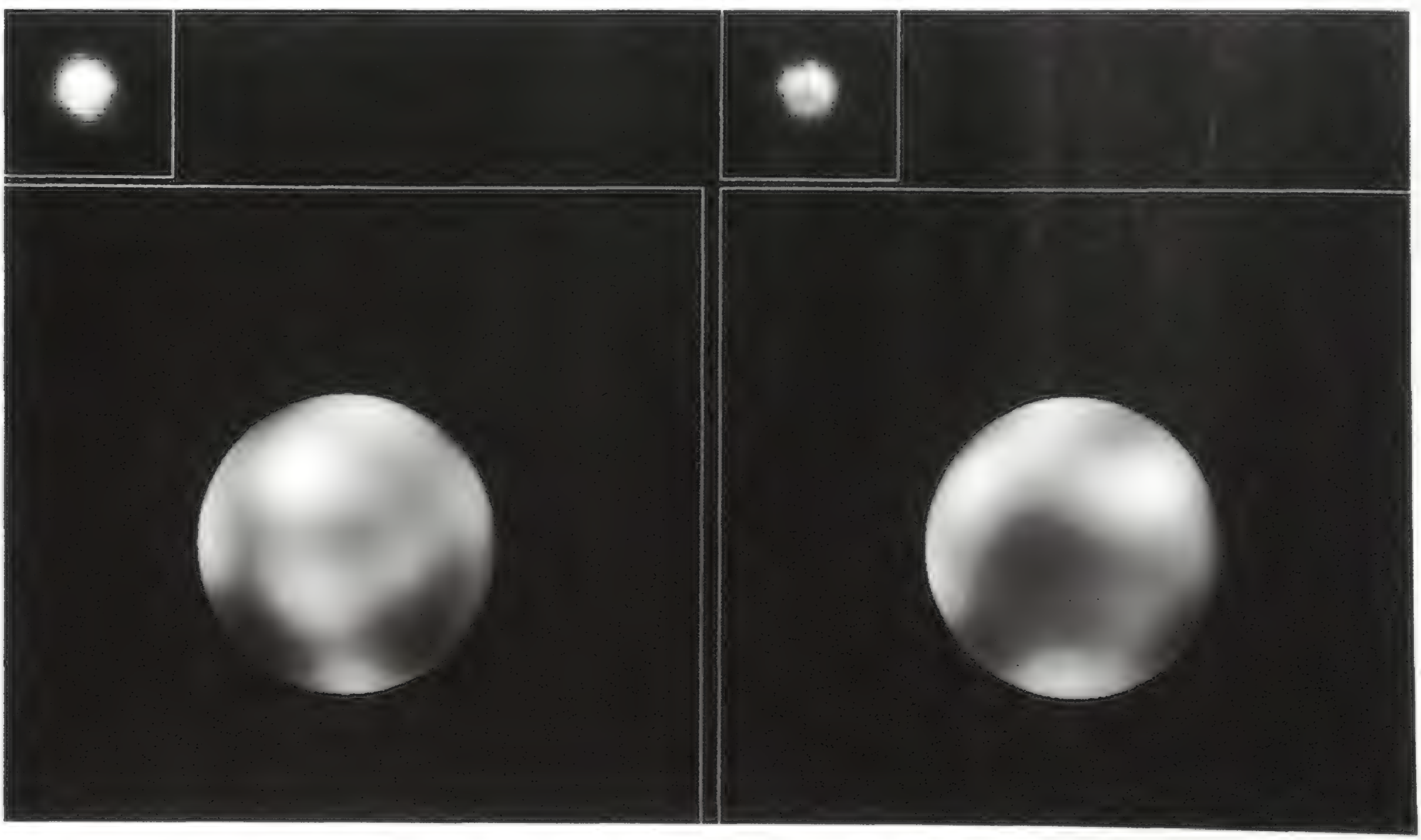
On March 7, 1996, Stern and Buie stood on a stage in Washington, D.C., and unveiled images from two of the four days of Pluto observations, along with flat maps they had made from the full set of pictures, plus global maps made from those. A month later they turned in their scientific paper to the *Astronomical Journal*, closing out the first phase of the project.

Both scientists continue working with the images, and already they've improved their maps since the NASA press conference. And what do the pictures show that's new? Not much, at least in the first analysis. Buie is pleased that his old, indirect maps turn out to be pretty accurate, except for one or two details. A bright spot near Pluto's equator, for example, appears in the wrong place in the old maps. The Hubble pictures also reveal two bright regions just above that. And the jury's still out on the north pole—Buie and another group had concluded it was dark, but the new Hubble pictures and another older map say it's bright. Unfortunately, this is an area where the Hubble data is less trustworthy, due to the blurring effects.

So Pluto is still a mystery. What Stern and Buie would really like is a regular monitoring program to look for changes as the planet gets colder and more snow falls on its surface. Stern may even put in a proposal to use a new Hubble camera scheduled for installation next year. Maybe he'll suggest taking pictures at more longitudes, or with different filters. But that's a proposal to be written another day.

Photographed by the Hubble Space Telescope in blue light, small images of Pluto's disk (in the upper corners of the pictures below) show 12 regions of varying brightness, possibly created by Pluto's patchy surface of methane ice and nitrogen snow. The larger images are computer-generated global maps based on four days of observations. Constructed from four separate images, a flat map (right) suggests that Pluto has a dark equatorial belt and bright polar caps.

ALAN STERN/MARC BUIE/NASA/ESA (2)



They were a ragged band of pilots smuggling goods into Mexico in a risky night-flight operation. They called themselves

THE CONTRABANDISTAS

by Homer H. Hickam Jr.

Illustrations by Steve McCracken

Harold "Swede" Larson, a retired Marine Corps pilot and veteran of the Central Intelligence Agency's Air America airline in Southeast Asia, arrived in McAllen, Texas, in 1980. He had spent some years kicking around the Isle of Man, running an equipment rental store in Oklahoma, and winding down from the Vietnam war, and he was getting the urge to fly again. Something interesting was going on in Texas, he'd heard: "The way it was told to me was that I could expect a lot of high-risk flying, would probably make a lot of money, and get to thumb my nose at two governments—just my cup of tea.

"When I arrived, I found pilots from all over the world—Alaska, Singapore, Arabia, Africa, anywhere they had scrounged up a job—pulling in like cowpokes at a roundup. Every restaurant and saloon in the valley was full of 'em."

In the late 1970s, the Mexican government had applied heavy tariffs to all electronic equipment manufactured outside Mexico, ostensibly to protect a fledgling domestic electronics industry. The effect of this protectionist legislation (besides pervasive corruption among government officials and retail distributors) had been to price most of these products outside the reach of the average Mexican consumer. So naturally enough, operations had sprung up to supply Mexicans with inexpensive duty-free goods from the United States.

"It was pretty straightforward," says Ben O'Neal, then president and owner of South Central Aviation in McAllen, Texas. "There was me, the air carrier; there was the man on the ground down there who received the merchandise and paid the money; and there were the warehouses on the Texas side of the border which supplied the electronics."

O'Neal got into the "electronic transport" business, as it was euphemistically known, around 1979. "I started small, with one pilot and a twin Beech for about a year, until one night an agent from Mexico City knocked on my door and said, 'Sit down and I'll tell you how we're going to make some real money.' Bottom line was, he represented certain Mexican interests who would protect us from everything but the army—and maybe that too." O'Neal hired a pilot, bought a DC-3 for around $85,000, and ripped out the interior to make a cargo hauler. "Then I got two Air America pilots—best move I ever made," he recalls. "Before it was over, I had two DC-7s, one DC-6, four C-46s, 11 DC-3s, a twin Beech, a Cessna 206, and a Howard 250. I was bigger than some airlines."

The pilots would show up at Miller International Airport in McAllen, seven miles from the border, late at night. Their aircraft would already be packed with boxes marked Sony, Hitachi, GE, Motorola. They'd warm up the engines and file a flight plan with the airport's Federal Aviation Administration flight service station, using some legitimate airport in Mexico as their destination. O'Neal explains: "We had to do this because it was against FAA regulations to fly to an international destination without a flight plan being filed and opened, and we were determined not to break any U.S. law. But we didn't want the United States government to have anything to do with us once we got across the border. I mean if we crashed or something, we didn't want to be on an FAA-opened flight plan—that would have given the United States a reason to investigate. So as soon as the pilot took off, he'd open the flight plan. Then when he got to the border, he'd close it as if he'd changed his mind." Once in Mexico, the "contrabandistas" would kill the navigation lights and transponder, which announces an airplane's presence to inquiring radar, and drop down to hug the terrain.

SWEDE LARSON

"I was told I could expect a lot of high-risk flying, would probably make a lot of money, and get to thumb my nose at two governments—just my cup of tea."

Before his death last September, Swede Larson recalled those flights: "It was glorious, skimming over that desert in the moonlight, using our wits as to minimum altitude and approach patterns." A few miles past the glow of the border towns, the contrabandistas flew into a darkness with no horizon. When the moon rose it revealed a tortured, corrugated desert, sinuous canyons giving way to jagged peaks ready to tear away wings and rip out the bellies of aircraft flown by incautious pilots. Eyes strained to find each landmark and, finally, the flickering lights of the airfield.

"Flying in Mexico was primitive," says Lyle Shunk, who had previously flown DC-6s for Transcontinental out of Detroit. "I came out of an environment which is cargo airlines, low approaches, and a lot of heavy instruments—east coast stuff. Down there, it was more of a VFR [visual flight rules, or clear-weather flying] operation.... Some of the guys killed themselves be-

cause they weren't careful with the terrain. It was just pure desert, sand and rocks, mountainous."

"It was some wild flying," says Gus Gustafson, like Larson a retired Marine and Air America vet. "Even taking off could get exciting, mainly because the aircraft were grossly overloaded. The DC-3s were rated to carry 26,900 pounds of cargo, but the contras were taking off with about 33,000 pounds. A lot of times the only way we got off was by sucking up the gear [pulling in the landing gear right after takeoff to reduce drag]. Then it was a long, slow climb to altitude before we'd go across the border."

"We did everything we could to minimize the risk, but it was there," says Ben O'Neal. "Before it was all over I would lose four pilots, two mechanics, and 15 airplanes in Mexico."

"When I stopped to think about it," Larson said, "I figured it was probably the most dangerous flying I had ever done, except for some heavy ack-ack around Pyongyang. But I was hooked on it, and the pay wasn't bad either." According to Larson, a DC-3 captain got $800 a trip and the copilot $400, and they made about 15 trips a month.

Just two miles from the destination airstrip, or *aeropista*, Larson would turn on the landing lights, and the welcoming committee on the ground would respond with a pattern of flickering flare pots. "As soon as we'd touch the runway or road or whatever the hell kind of clearing, the Mexicans would put out their lights so no one could follow us in," Larson said. After landing, the crew would go squat among the cacti, poised to run if trouble cropped up, while trucks backed up to the cargo door and emptied the aircraft. Then Larson and his

copilot would jump back on board and apply full throttle. "We'd never stop our engines and we'd never pay attention to the wind," he said. "I could see men on horseback and others in blacked-out pickups taking off with the contraband. They all seemed to have guns."

Though their contact with the villagers was often fleeting, on one occasion Larson and his copilot, having crashed on takeoff, passed several pleasant days at the village where they had made their delivery. When they were ready to leave, the villagers loaned them two burros. "A young man took us in tow and we started out, my feet touching the ground from the back of a burro," remembered Larson. "When we reached the highway and an isolated bus stop, we gave our guide many thanks. He went off, leading the burros and waving goodbye." Larson would return to repay the kindness, flying in a Cessna 206 loaded with kerosene stoves, leather-working tools, knives, pots and pans, and food for the village.

Not all the Mexicans welcomed contrabandistas. Back when goods were trucked into Mexico, customs officers would collect a payment at every stop the truck passed through. "With the airplane, we were flying over these checkpoints and avoiding payoffs," says Shunk. "The guys in between weren't getting their cut, so heaven help you if you flew over these areas. I got chased twice by a gunship. They would capture airplanes, a Cessna or an Aztec, cut portholes in the side, and fly alongside and shoot at you."

Then there was the Mexican government. One night in 1981, recalls Shunk, "Swede and I were landing on the ex-governor's paved strip in Hidalgo. It was about midnight. We were just starting to unload the airplane. I heard a pistol shot and Swede yelled, 'We're being raided!' so I tried to get us out of there. I didn't think we'd get off, but I figured we might get down to the other end and get out of the airplane and into the bushes.

"We were gunning down the runway, but they ran alongside us in a truck, standing in there with rifles, firing at us. They disabled the right engine, flattened the tires. They put over 200 bullets in the airplane. You could hear the TVs *pop-pop-pop*-ing back there. I just stopped. It was all over. Swede went back to get out while I shut things down. When I got out they had him lying face down, and I thought, *Oh God, they've shot old Swede!*"

They hadn't, but they kept the two contrabandistas tied up for some 15 hours. Later, Larson and Shunk learned that their captors, who were dressed in street clothes, were soldiers of the Mexican army. The fliers were taken to a holding cell at a military base.

"My wife didn't know where I was for about three days," Shunk says. "They knew Swede was okay—he had managed a phone call. But I was just stuck. Finally the word got out and at least my wife knew I was alive."

LYLE SHUNK

"I got chased twice by a gunship. They would capture airplanes, a Cessna or an Aztec, cut portholes in the side, and fly alongside and shoot at you."

With all his years of military and CIA flying, Larson took the capture in stride. "We were caught and that was that, so I figured I might as well be philosophical about it," he said. "We went to the pen in Pachuca. It was the best break we got outside of the army not shooting us. I'd been in worse motels in the States. We had soccer on the weekends, schoolteachers came in to educate the troops, we could garden, and we could even call home once a week. My wife came down and brought me a radio. That was great, listening to football games on Texas stations."

Larson kept busy organizing the prison library, drawing cartoons, and hatching escape schemes with his buddies in Texas. "I wrote an operations plan for escape with a number of options, from going over the wall to having a helicopter come in," he recalled. "Our attorney negotiated a deal before we had to do it, but we were ready."

"Basically, we bribed our way out," Shunk says. "We were told right up front if we could pay $120,000, we could leave. They figured the load was $60,000 and they doubled it. Our attorney got a lower figure. My boss ended up putting in $15,000. I put in $12,000. Other pilots put in a thousand here, a thousand there."

As soon as Shunk was released from prison, he went home to Detroit. "My wife never would have tolerated me staying down there," he says. "It was winding down anyway."

In June 1982, Mexican customs officials shot down three smugglers' airplanes and captured the pilots. Operation Eagle, a cooperative effort between the Mexican and U.S. governments to stop the smuggling, had begun. The Mexican treasury calculated that the country was losing $6 million a month to the contraband business, and the government decided to get serious about the smuggling. Mexico agreed to provide intelligence on drug traffic along the border in exchange for U.S. information on the contrabandistas. The interdictions that resulted, combined with a series of peso devaluations, began to take their toll, and the "electronic transport" companies started folding.

Fortunately for Mexico, there were still contrabandistas around in September 1985, when an immense earthquake

left thousands of people in Mexico City trapped under rubble and thousands more dying. Ben O'Neal recalls: "As soon as it was clear it was a real mess down there, I went to see the Mexican consul general in McAllen.... I said: 'Look, I can help you out. I've got the means to put anything you want down there.' He agreed and wrote me out a letter for each pilot to show the authorities in Mexico City. I started to call around and get things organized. We taped big red crosses on our planes and started flying the next day."

Contrabandistas and other pilots packed airplanes with food, drugs, medical equipment, compressors, tools, blankets, and flashlights, all donated by Rio Grande Valley citizens and businesses. The pilots donated their time and company owners like O'Neal paid about $4,000 per flight.

By then the smuggling operations were almost over. "I'll tell you something," says Shunk, "I wouldn't take a million dollars for the experience. It was some of the best, most enjoyable flying in my life, a natural high. But I wouldn't give a plugged nickel to have it all happen again either, especially getting captured and spending time in jail. I'm back into normal aviation now, flying, being a mechanic, and doing short hauls. That's enough for me."

"To really enjoy flying, you've got to have some adrenaline flowing, and every trip down south provided that," says Ben O'Neal, who is now retired in Gunnison, Colorado. "I miss it. It was almost like combat. In all, I think there were 62 pilots killed down there. One day I want to put a plaque at the McAllen airport in their memory. They were really great guys."

COMMENTARY:

Promises to Keep

Why should the United States spend scarce dollars to send people into space? That's an issue we haven't agreed on as a nation for 25 years.

The answer was clear in the 1960s. We were competing with the Soviet Union around the globe and in space. And in space we were losing. President Kennedy's response was to challenge the Soviets in the same arena in which they were asserting superiority. Demonstrating to the world that American democracy was superior to Soviet communism was clearly the reason our nation made a major commitment of resources to Apollo.

Today the clarity of purpose that characterized Apollo is gone. In its place, we hear a variety of arguments for sending humans into space, with the four most often cited relating to economic benefits, knowledge, foreign policy, and intangibles such as the pride and awe we derive from our space accomplishments.

Although all these reasons have merit, not all have merit enough. The danger is that expectations will develop from weaker, shortsighted justifications. And when those justifications prove flawed, the rug will be pulled out from under us. We might lose a program, and even the future of space exploration itself might be jeopardized. We must be very careful not to promise things we can't deliver.

ALAN E. COBER

Let's consider the economic benefits argument. There are some sound ideas here. First, technologies developed for use in space and space capability itself will lead to new products and markets, benefiting our national economy broadly. Second, space activities are a means to sustain a scientific and technological workforce that can be called upon to serve the nation in other ways.

The problem with both of these arguments is that they provide little or no direction for the space program. They lead us to judge space proposals by the number of jobs created or sustained, or by anticipated economic gains. Space is thus set in competition with other means of employing scientists and engineers and becomes subject to the vicissitudes of economic projection. As one projection replaces another our space goals shift, casting doubt on our direction. The many headlines declaring NASA "Lost in Space" following the loss of *Challenger* illustrate the public doubt that is aroused when economic promises—in this case, promises of reliable, low-cost access to space—are used to underpin our space program and then not fulfilled.

The knowledge argument is another problematic area. On the one hand, one of the great triumphs of nearly four decades in space is the knowledge we have gained about our planet, our so-

Carl B. Pilcher cautions against doing the right thing in human spaceflight for the wrong reasons.

lar system, and the universe beyond. We have also learned much about how humans and other organisms react to weightlessness and how physical processes like fluid flow and combustion are altered in zero G. Some of the most important gains have been in our knowledge of Earth. From space we view Earth as an integrated system of atmosphere, oceans, crust, and biosphere, enabling us to begin untangling the complex processes of global change. Study of other planets has provided context for our understanding of Earth as a planet, and has opened up inspiring vistas for exploration and discovery. We have come to understand better the behavior of the sun on which all life depends and appreciate the enormity of a universe of countless suns stretching back to the beginning of time.

But most of the information on which this knowledge is based was returned by robotic spacecraft. Laboratory studies by Earth-orbiting crew are valuable scientifically, but much of this information could be obtained robotically as well. Understanding human response to the space environment is also valuable scientifically, but the primary reason for developing this understanding is to enable more ambitious human space endeavor. It is thus hard to justify human spaceflight on the basis of knowledge gained.

The area of foreign policy places us on firmer footing. For three decades of human spaceflight, winning the cold war was one of U.S. foreign policy's defining goals, underpinning governmental support not only for Apollo but for the space shuttle and, initially, the space station as well. In the aftermath of the cold war, forming bonds and learning to work with Russia has become a national priority. Human spaceflight is a visible, ambitious arena for such cooperation. At the same time, it is also an arena for strengthening bonds with our traditional space-faring allies. This combination of foreign policy objectives now largely underpins U.S. governmental support for the international space station.

Some in Congress express support for the space program for emotional reasons, but demand tangible benefits to the nation to justify public expenditures.

To support an enduring space program, a foreign policy goal must be enduring as well, with a nobility of purpose that can attract broad political support. Such a goal, comparable to winning the cold war, was recently articulated by Speaker of the House Newt Gingrich: to bind together the free peoples of Earth. In a speech at the Center for Strategic and International Studies in Washington, D.C. last summer, Gingrich argued for a dramatic increase in our human spaceflight ambitions: "We ought to be back on the moon, we ought to be on Mars...with all the free nations of the planet participating, so that we build a momentum of the human race working together to reach out beyond the Earth."

This idea is inextricably linked with the fourth of our human spaceflight justifications, what I call the "intangibles." Perhaps more important than demonstrating that the United States could beat the Soviet Union to the moon, the Apollo program became the standard by which we judged ourselves as a nation. A phrase entered the lexicon: "If we can land a man on the moon, why can't we..." And we finished it with the most urgent social goals of the day: end hunger, end poverty, cure cancer. We reasoned that if we could be great in one area, we could be great in others as well.

Inspiration, hope, pride, adventure, a vicarious sense of danger, the excitement of discovery—all are intangibles that connect individuals to our achievements in space. Space is a venue for accomplishing the impossible and knowing the unknowable. Whether it's walking on the surface of another world or unraveling the almost unfathomable mysteries of black holes, space has the power to humble and awe.

The spiritual connection to space is a particularly problematic justification for spending public funds. "Tax dollars are to support the public good, not the

Assistant Associate Administrator for Strategic and International Planning in the Office of Space Science at NASA Headquarters, the author is responsible for strategic planning and other long-range aspects of space science and exploration.

individual spirit," the argument goes. Indeed, some in Congress express support for the space program for emotional reasons, but demand tangible benefits to the nation to justify public expenditures.

Yet the intangibles are fundamental to our character as humans. When people weep at a launch of the space shuttle or at the heroism and achievement captured in the recent movie *Apollo 13*, they are demonstrating a connection to space that is not intellectual but visceral. The abundance of ancient space travel myths and the linking of the heavens to the gods are testimony to this spiritual connection.

Buzz Aldrin, the second man to walk on the moon, tells a story. After returning to Earth, he was puzzled to find that people were driven to tell him exactly where they were and what they were doing when humans first walked on the moon. But as the phenomenon continued, year after year, he realized that the people he met had experienced something profound and that they wanted to share that experience with someone who had been part of it. This indeed is what the space program is all about: human experience. When we lose sight of that, we go astray.

I believe these two key elements—nobility of purpose and appeal to the human spirit—can form an enduring underpinning for publicly funded human spaceflight. To succeed, however, we must have goals in space that are as majestic as our reasoning. They must be attainable, of course, but grand and inspirational as well—capable of capturing the spirit and imagination of the world. As Gingrich put it, "You don't hold together the free people of the planet by small things."

NASA Administrator Daniel Goldin recently outlined such a goal in a speech at the National Academy of Sciences: the human exploration and, ultimately, settlement of Mars. Mapping out a plan relying on technological innovation and economic opportunity rather than brute force, he said, "Our rockets won't just take us to Mars, they'll open the space frontier."

We must be very careful not to promise things we can't deliver.

We must be clear from the start that the goal is sustained human activity on Mars—"emigration, not invasion," as Goldin put it—beginning with a human mission to Mars in 2018. The initial focus will be exploration of the planet, particularly to answer the question "Did life ever arise on Mars?" The establishment of human outposts will lead eventually to self-sufficient human settlements. The mechanisms—technical, political, economic—for these later phases need not be specified now or even in the near future, but we must be clear that 2018 is a beginning, not an end.

Why 2018? Because it's feasible technically, politically, and economically. The relative positions of Mars and Earth at that time will allow us to travel to Mars with a minimum of fuel. Going in 2018 allows time for research on how to ensure the health, safety, and effectiveness of the Mars crew. It gives us time to find water and other resources on Mars that will enable humans to "live off the land." It's consistent with our international commitments to complete the space station, essential for humans-in-space research. Finally, it can be achieved at current levels of spending without sacrificing other valuable space projects, if we draw on the combined space budgets of the free world.

Yet 2018 is not so far off that we can wait to get started. There are several things we must do now. First, consult with other nations from the very beginning to form a true partnership of the planet. Second, direct current human spaceflight spending toward this goal: Emphasize using the international space station for research on humans in space and ensure that post-space shuttle planning includes rockets that will get us to Mars. Finally, design into the program frequent, exciting, inspiring milestones involving both humans and robots in space. One possibility includes using robotic hoppers and miniature rovers to survey Martian terrain, look for signs of ancient life, and locate usable water and other resources, followed by the return of Martian samples. We should also embark on a series of increasingly ambitious human forays beyond low Earth orbit, perhaps first to the moon and then to an Earth-approaching asteroid, to test both the machines and the procedures we will use to land on Mars.

The human exploration and settlement of Mars is a challenge at least on a par with any ever undertaken by humanity. As President Kennedy said of Apollo and other endeavors that test our limits, "We choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard." Believing we can achieve greatness requires first the courage to undertake extraordinary challenge, then the commitment to see it through.

THE SMITHSONIAN TRAVELER

■ TO REQUEST TOUR AND SEMINAR BROCHURES, CALL (202) 357-4700.
■ OR WRITE TO STUDY TOURS & SEMINARS, MRC 702, WASHINGTON, DC 20560.

Call or write for your FREE **Smithsonian Study Tours & Seminars** catalogs, featuring more than 300 educational tours to 250 exciting destinations in the United States and abroad!

Smithsonian Study Tours and Seminars offer unparalleled educational travel opportunities. Enjoy traveling with engaging study leaders and fellow Smithsonian Associates.

International Tours

City Interludes June-November 1996: Extended stays in some of the world's great cities: London, Paris, Venice, Florence, Hong Kong, Kyoto, Vienna, Berlin, Prague, Istanbul, St. Petersburg, Hamilton (Bermuda).

Countryside Tours June-October 1996: Relaxing sojourns in France, England, Scotland, Wales, Austria, Switzerland, Italy, Hungary, and the Czech Republic.

A Merchant's Passage to South America September 21-October 18 and/or October 13-November 12: Aboard the *M/V Americana*.

Danube River Journey September 25-October 8: Aboard the *Heinrich Heine*.

The Rhine, Main and Mosel Rivers October 2-13: Aboard the *Theodor Fontane*.

The Islands of Indonesia: Sumatra, Java and Bali October 2-21.

Insights into England's Heritage October 5-17.

Tunisia: Legends and Traditions October 6-18.

Voyage to Ancient Lands: Turkey, Syria and Jordan October 8-24: Aboard the *Regina Renaissance*.

Israel: Ancient and Modern October 15-27.

Mystery Lover's England October 20-31.

Hong Kong to Singapore October 23-November 5: Including the Eastern and Oriental Express.

U.S. and Canada Tours

Smithsonian "Anytime" Weekend (Washington, D.C.)
Value package includes two nights accommodations, lunch in the Associates Court, a private tour of the Castle and much more. Choose from four hotels: Loews L'Enfant Plaza, Mayflower Hotel, Holiday Inn Capitol and the Channel Inn. Prices begin at $215, including parking. This is a great family vacation.

Exploring Alaska's Inside Passage and British Columbia August 31-September 11: Aboard the *Sea Lion*.

Pacific Northwest Coast Indian Art and Culture September 4-11.

Legend of Lincoln (Kentucky) September 13-19.

Art Capitals by the Sea (Boston to Washington, DC) September 13-25: Aboard the *Nantucket Clipper*.

Arkansas River Voyage September 18-26: Aboard the *Delta Queen*.

Scenic Western Landscapes (CA,AZ,NM) October 11-20: Aboard the *American Orient* Express and *Yorktown Clipper*.

Smithsonian Seminars

Concentrated study of specific topics.

Ecology of the Olympic Peninsula (Washington) August 4-9.

Chautauqua Institution: The Value of the Spoken Word (New York) August 11-17.

Spies in the Skies: US Aerial Reconnaissance (San Diego) August 20-25.

Telluride Film Festival (Colorado) August 29-September 3.

Civil War:Petersburg to Appomattox (Virginia) September 12-15.

Navajo Pottery and Weaving (Durango, CO) September 12-18.

Maine's Maritime History (Southport Island, ME) September 18-22.

Aircraft Restoration (Washington, DC) September 22-27.

Odyssey Tours

Moderately-priced tours with several departure dates in 1996.

France Through the Ages 16-day tours in September or October.

Eastern and Central Europe 18-day tour in September.

Scottish Islands and Highlands Cruise August 1-10: Aboard the *Explorer*.

Egypt and the Nile Cruise 12-day tours in September or October.

Jordan and Israel 18-day tours in September, November or December.

For an Odyssey brochure, call 1-800-932-8287.

Ask questions, compare notes, meet interesting people—every Wednesday, May 1 through July 31, from 9 P.M. to 10 P.M. (Eastern Time). Join us for Smithsonian Travel Talk in Smithsonian Hall on America Online (keyword: Smithsonian Travel). Chat with Study Tours and Seminars staff and fellow Associates about traveling with the Smithsonian, and be sure to sign up for the Study Tours and Seminars electronic mailing list. Door prizes include travel books and luggage tags.

THE LATEST WORD ON TOURS AND LEARNING ADVENTURES

The Sorry Saga of THE BREWSTER BUFFALO

NASM

Or was this World War II fighter really just a turkey?

by Daniel Ford

When it comes to candidates for the worst fighter of World War II, one airplane usually leads the list. There are two books entitled *The World's Worst Aircraft*, and the Brewster Buffalo is the only fighter from any era to rate a chapter in both. When the Royal Air Force received Buffaloes, it fobbed them off on the Fleet Air Arm or sent them to the Far East, a clear indication of dislike. It also manned them mostly with Australian and New Zealand pilots, perhaps an even stronger statement. When they flew the Buffalo against the nimble fighters of Japan, they often didn't come back. Yet the Buffalo's story is not completely one-sided. Pilots thought it was a sweet airplane to fly, and the Finns used Brewsters to great effect against Soviet aircraft from 1941 to 1944.

The Buffalo's story begins in 1932, when an aeronautical engineer named James Work paid $30,000 for the aircraft division of Brewster & Co., a firm that over the years had built horse-drawn buggies, auto bodies, and aircraft assemblies but now did little more than represent Rolls-Royce in the United States. Jimmy Work was a balding man with soulful eyes, a gentle smile, and a good suit. You might have picked him to manage your retirement account—though it probably would not have been a great idea. Serving as president of Brewster Aeronautical, he hired himself as a consultant and leased a factory from himself. Double-dipping in this fashion, he landed contracts for seaplane floats and wing panels, mostly for Grumman. But what he really wanted to do was build his own airplanes.

Enter chief engineer Dayton Brown, like Work a veteran of Detroit Aircraft and the government-owned Naval Aircraft Factory. "He wasn't like a boss, he was like a fellow worker," recalls Walter Musciano, who worked under Brown as a draftsman at Brewster in 1939. "He asked you questions and he listened to the answers. He was the greatest man I've ever worked for. To me he was 'Mr. Brown,' but when I called him that he always said 'Dayton.' " In a photo taken a few years later, when the Navy visited Brewster in an attempt to straighten out the mess Jimmy Work had made of it, Brown stands with folded arms, wearing a double-breasted suit and a skeptical expression.

For Brewster's first product, Brown drew a slender, midwing dive bomber with retractable landing gear and an enclosed bomb bay. This was wonderful stuff for 1934, and the U.S. Navy bought the rights to build it at the Naval Aircraft Factory as its first carrier-based monoplane. That was a nice

compliment to Brewster Aeronautical, but didn't advance its hopes of becoming a warplane manufacturer.

Brown redrew his airplane as a two-seat fighter, then a one-seater. Among other innovations, it had a semi-bubble canopy, giving the pilot a clear view to the rear. The Navy liked the sketch enough to start a development project for the F2A (fighter, second, with the "A" designating the Brewster company).

Grumman provided a more conventional design. On its F4F, the canopy was faired into the rear fuselage, to protect the pilot if the airplane flipped over. (Brown provided a roll bar behind the seat for this purpose.) And the F4F was a biplane; the biplane configuration meant shorter wings, so more airplanes could be stowed on a carrier's deck.

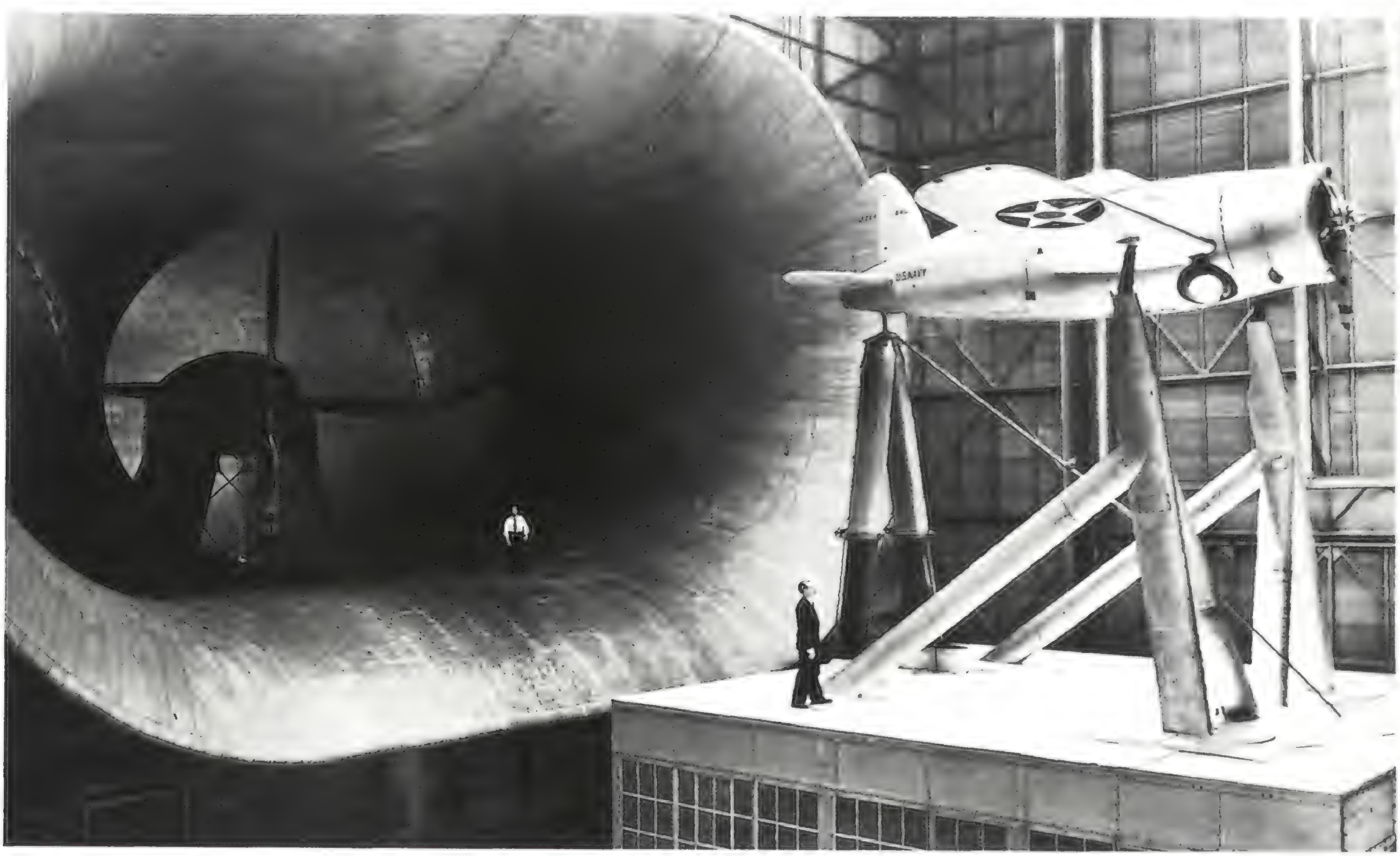
But this was 1936 and the trend was toward the sleeker monoplane, so Brewster got the nod. Grumman promptly took one wing off its fighter and created what history would know as the Wildcat. Apart from its "turtleback," this F4F-2 looked rather like the Brewster fighter. Both had a short nose (so the pilot could see the deck in front of him) and a single wing at the fuselage's midpoint. Each was distinctly plump. This was especially true of the Brewster fighter, whose engine had a bigger circumference than the Wildcat's.

Ah, that engine! Airframe manufacture was nearly a cottage industry in the 1930s, with machinists hand-crafting parts and seamstresses sewing fabric onto control surfaces. The cost of entry into the field was so small that the United States had 20 companies, each turning out a dozen or so warplanes a year, but only two providers of air-cooled radial engines powerful enough for combat. Grumman eventually equipped its Wildcat around the Pratt & Whitney Twin Wasp, a two-row engine with 14 cylinders and a two-stage super-

COURTESY JIM MAAS (2)

Jimmy Work (seated) guided the Brewster company into the airframe business and eventually out of business altogether. Standing on each side of him are the Miranda brothers, whose arms deals eventually landed them in jail (the man in the white shirt is unidentified). Buffalo designer Dayton Brown stands in the rear.

Wind tunnel testing of the XF2A at the National Advisory Committee for Aeronautics' Langley, Virginia facility found ways to increase the airplane's top speed by 31 mph.



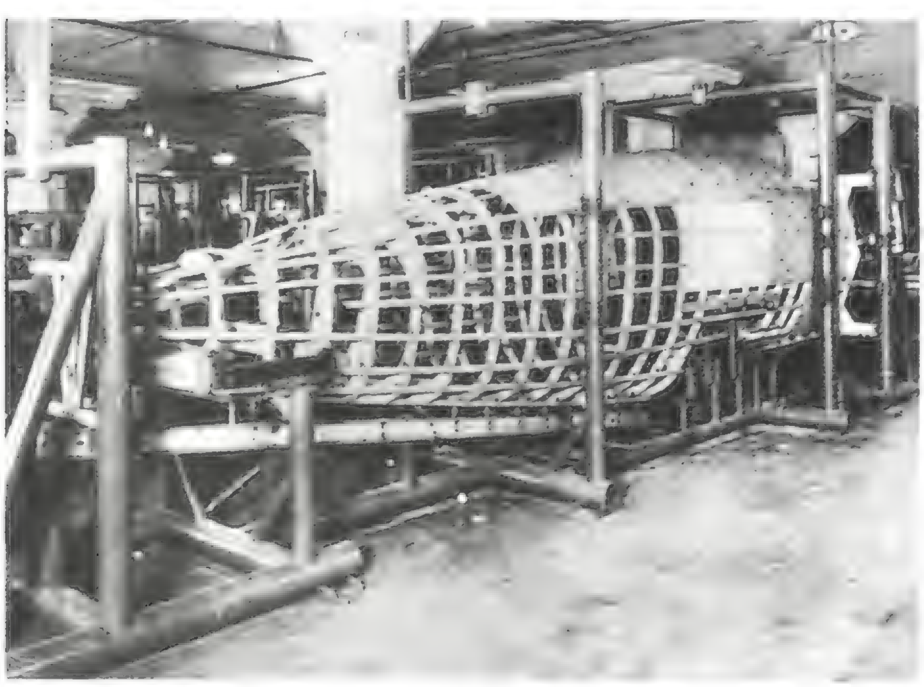
NASA LANGLEY

charger to ram the fuel-air mixture into them. Brewster opted for the Wright Cyclone, an older design with one row of nine cylinders. It had a one-stage supercharger, and its 950 takeoff horsepower fell to 750 hp at 15,000 feet. Early Cyclones—those supplied for the Brewster fighter—also had lubrication problems.

There was another flaw that beset the Brewster fighter. If the pilot set it down hard—and hard landings are the norm on an aircraft carrier—the main landing gear struts sometimes buckled two inches below the pivot point on the wing. The Brewster gear did have one advantage over the Wildcat's: it was operated by hydraulics. "Brown was hydraulic-happy, which was ahead of his time," says Musciano. "The Buffalo's landing gear retracted hydraulically. The Wildcat had a hand crank with a chain drive. The pilot had to hold on to the stick with his left hand and crank up the landing gear with his right. If you've ever seen footage of a Wildcat taking off, you see that they wobble" as the pilot struggled to crank the gear up.

The Navy tested the Brewster and Grumman prototypes in 1938. The F2A handled like a sports car, the F4F-2 like a pickup truck, and the Brewster's Cyclone seemed a safer bet

Though in some ways an advanced design, Brewster's fighter was soon outclassed. Low-tech manufacturing facilities also proved a burden.

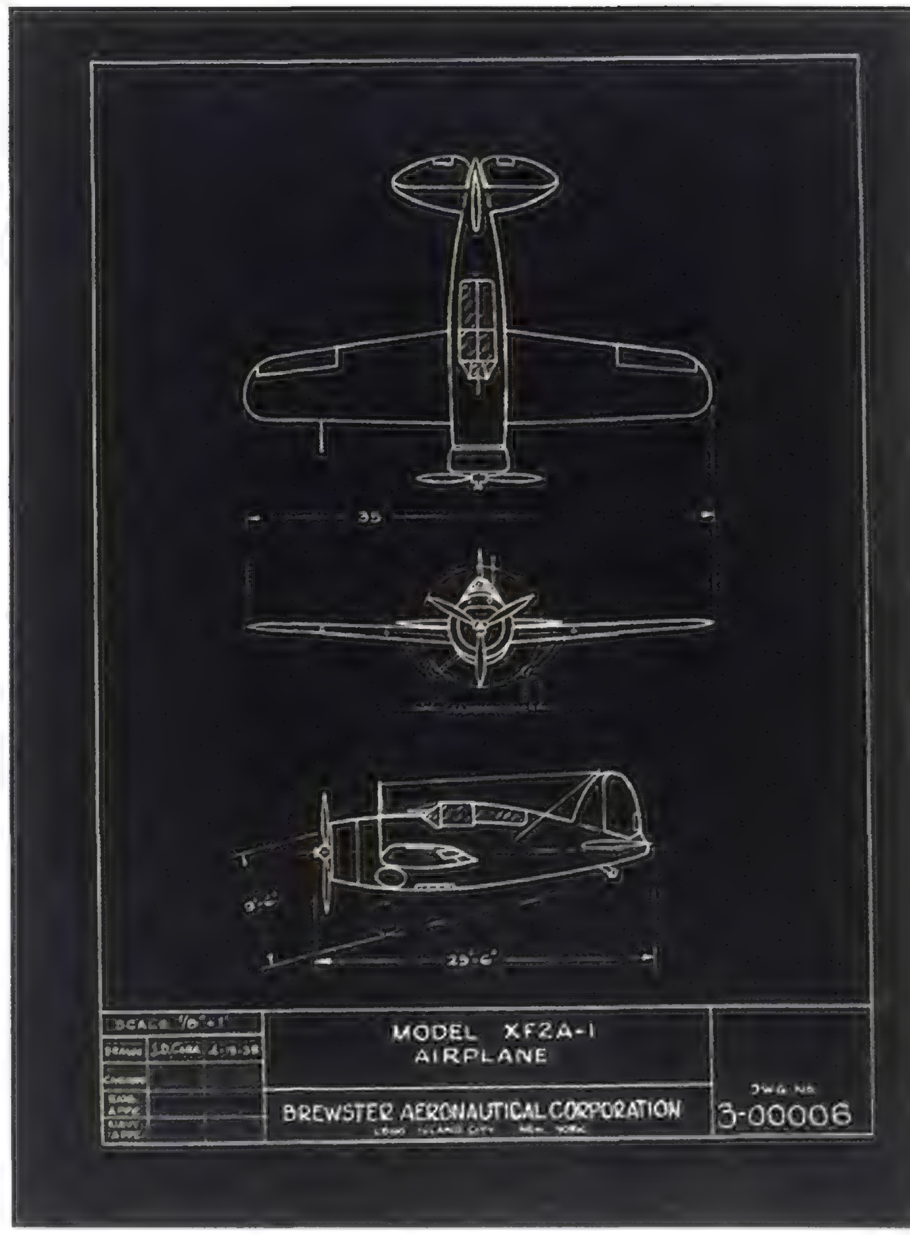


than the complicated Twin Wasp. Brewster got the contract for 54 planes. It delivered one in May 1939, another in July, and a third in October. The pace picked up after that, but at year's end the Navy still had only 11 Brewsters, not quite enough to equip its first monoplane fighter squadron, the carrier *Saratoga*'s VF-3.

The Brewster factory, an old automobile plant in urban Queens, across the East River from Manhattan, proved a major bottleneck. Parts were manufactured on four stories, brought together by freight elevator, assembled, then taken apart so the airplane could be trucked out to Long Island's Roosevelt Field to be reassembled for flight testing.

Meanwhile, Grumman installed a 1,200-hp Twin Wasp in

NASM



the third variant of its fighter, the F4F-3. Brooding over the slow pace of deliveries from Brewster, the Navy decided to hedge its bets by ordering 54 of the higher powered Wildcats in August 1939.

One month later, Germany attacked Poland. Dayton Brown's airplane was about to go to war.

The United States wouldn't enter World War II until after Pearl Harbor, but U.S. companies learned to benefit from the increasing tensions around the world. "From 1935 until the outbreak of the second global war, the American aviation business transmuted into an international munitions industry, a status it has kept ever since," author Wayne Biddle noted in his book *Barons of the Sky*. Biddle quoted the *New York Journal and American* from May 1938 as reporting that the dollar value of aircraft products exported in the first quarter of 1938 had increased 99.3 percent over the previous year's figures.

Brewster made its first export sales to Finland, which had been attacked by the Soviet Union, at the time a German ally, in November 1939. I can remember my father arguing that "little Finland" deserved our help: Unlike larger and richer countries, it had repaid its World War I debt. The Department of State evidently agreed, for it asked the Navy to release the rest of its Brewsters in exchange for a more powerful model the following year.

As required by the 1935 Neutrality Act, Brewster modified the F2A by replacing its government-supplied engine, gunsight, and direction finder with export-approved equipment. It took out the life raft and arresting hook, and doubled the firepower by installing two .50-caliber machine guns

NASM (2)

Ironically, this ad touting the Brewster's role in the Pacific appeared in December 1941. By then the Navy had put the fighters on two carriers, including the Lexington *(opposite).*

in the wings. (Like most U.S. fighters of the time, the F2A had two nose-mounted machine guns, synchronized to fire through the propeller arc.) The company produced 44 of these "de-navalized" fighters under the designation Model 239. They went by boat to Norway, then by train to Sweden, where they were assembled by Norwegian air force mechanics under the supervision of Brewster engineers. The Americans didn't lack for smokes or news of the Brooklyn Dodgers: Their buddies in Queens had stuffed the wing panels with cigarettes, magazines, and newspapers.

In February 1940, Lieutenant Joppe Karhunen traveled from Finland to Sweden to test the Brewster. When his engine seized up he made a belly landing on a snow-covered field, and damaged the propeller and some plexiglass belly panels. (Like many Navy airplanes, the Brewster had a view window under the pilot's feet.) A few days later a former Navy pilot named Robert Winston arrived in Sweden. He had been hired by Brewster to test the Model 239, and he liked what he found. "This ship was a pilot's dream," he recalled in a wartime memoir, *Aces Wild.* He praised its cockpit layout, power ("the two-ton airplane left the ground like a skyrocket"), and stability.

In Sweden Winston found the Finns disenchanted with their new acquisition, so he set up a mock dogfight with an open-cockpit Fiat Freccia from Italy. The Fiat was faster in level flight, but the Brewster could turn inside it, allowing Winston to stay on the Italian's tail until the other pilot fled the battle. "*Mycket bra!*"—very good!—Karhunen shouted when Winston landed. "*Mycket* damn *bra!*"

Alas, for the Finns, the Winter War ended in March 1940, with the Soviet Union occupying southeastern Finland, before any Brewsters reached the front.

Dayton Brown had now readied the improved model for which the U.S. Navy had released its airplanes to Finland. Equipped with the 1,200-hp Wright Cyclone, the F2A-2 had a top speed of 340 mph and a range of 1,600 miles—at one time the longest legs of any fighter in the world. In an effort to prepare for an attack by Germany, Belgium bought 40 Brewsters from the export firm of Alfred and Ignacio Miranda, who had previously sold arms to Bolivia, Japan, and Spain, sometimes conniving to circumvent government regulations to do so. Once again, the U.S. Navy found itself obliged to yield up its Brewsters to a small European nation.

The result was the Model 339, but Germany reached Belgium before the airplanes did. France took over the order, but it too surrendered before the airplanes arrived. Then Britain acquired the Brewsters. The Royal Air Force assigned them to 71 Squadron, made up of Americans who had volunteered to fly for Britain. The Yanks put the 339 through its paces at Church Fenton in Yorkshire. Squadron leader Walter Churchill, a Dutch-born Englishman with seven German shoot-downs to his credit (and no kin to the wartime prime minister), complained that the fighter had no armor plate and not enough guns. Worse, its fuel tanks were part of the wing structure, so a single bullet hole could require a major rebuild rather than just the removal and replacement of the damaged tank. The tail wheel wobbled. The clock had no trip indicator, so the pilot couldn't tell when to switch fuel tanks. "On no account should this type be considered as a fighter without considerable modification," Churchill concluded. However, he thought it would make a dandy trainer: "It behaves with the ease of a Gladiator [biplane] and is just as simple to aerobat. So far we have found no vices."

So 71 Squadron used the Belgian Model 339s as trainers. A few went to the Fleet Air Arm in the Mediterranean to serve with 805 Squadron on the beleaguered island of Crete. Only one ever set out on a combat mission, flown by a former Member of Parliament named Rupert Brabner. He turned back when the engine sounded rough, lost power before reaching the runway, and flipped the Brewster onto its back. Dayton Brown's roll bar did its job, and the former MP survived. The airplane did not: Along with the rest of the Brewsters 805 Squadron had on Crete, it was captured when German paratroopers seized the island in May 1941.

Like the Brewsters or not, the British couldn't build enough Hurricanes and Spitfires to defend their far-flung colonies, so they ordered 170 more Model 339s to their own specifications. Anyhow, in March 1941 Congress passed the Lend-Lease Act, and for all practical purposes Britain could acquire the U.S. warplanes free of charge.

Lend-lease posed a problem for Brewster Aeronautical. Accustomed to up-front money from foreigners, it now had

to wait for the U.S. government to pay. This difficulty was followed by others. For their arms deals in Bolivia—which the U.S. government had placed under a munitions embargo—the Miranda brothers were sent to the Federal penitentiary at Lewisburg, Pennsylvania. And the Navy eased Jimmy Work out of the presidency, hoping to speed up production by installing a Naval Academy graduate named George Chapline.

The RAF had a tradition of fierce alliteratives: Hawker Hurricane, Gloster Gladiator, Vickers Vildebeest. It christened the Model 339 "Buffalo," a name so apt that it was soon applied to all models of the Brewster fighter. Thanks to the modifications the RAF demanded, it weighed 900 pounds more than the equivalent F2A-2. Speed dropped, along with climb rate, service ceiling, and maneuverability. To make matters worse, Brewster shipped some of the British 339s with second-hand Wright Cyclones cannibalized from the TWA passenger fleet.

The British had a triage system for allocating warplanes, reserving the Spitfire for home defense, sending the Hurricane and the Curtiss Tomahawk (the P-40 in U.S. Army service) to North Africa, and exiling the Buffalo to Southeast Asia. This was not the best place for it, to judge by the comments of test pilot Eric Brown: "Delightful maneuverability. Above 10,000 ft. labors badly. Oil and cylinder head temperatures high in temperate climates." If the Cyclone overheated in Britain, how would it fare in the tropics?

No matter! "Buffaloes are quite enough for Malaya," said Air Marshal Sir Robert Brooke-Popham in Singapore, five days before Japan proved him wrong. It was an article of faith in the West that the Japanese could neither build decent warplanes nor fly them effectively.

Vic Bargh was one of the New Zealand lads who left their pretty farms to defend the British fortress at the southern tip of Malaya. "When we got to Singapore," Bargh says, "we thought we'd see all sorts of modern aeroplanes." Instead, they were given creaky Vildebeest torpedo planes. So Bargh was delighted when Buffaloes arrived: "They were beautiful aeroplanes. We all thought they were good, you know. We didn't know they were out of date."

That fall, Vic Bargh and his mates were sent to Burma, where they anchored the supply line to Singapore. By December there were five Buffalo squadrons in Southeast Asia, each with British commanders, a few junior officers from Australia or New Zealand, and a dozen sergeant-pilots like Bargh. As with the Ascot races, so with the RAF in 1941: You needed the right accent to get into the clubhouse.

Below Singapore lay the oil-rich islands of Sumatra and Java, where the Dutch had a colonial air force. They bought Brewsters too, and some of these were also delivered with second-hand engines. In the United States, the Navy finally got enough Brewsters to equip VF-2 on the *Lexington*. Like the RAF, the Navy wanted more fuel, more armor, and more ammunition. The result was the F2A-3—the sports car trans-

NASM

In a rare color photograph, a Brewster shows off its lines—and underscores why the name Buffalo was so apt.

formed into a slug. In a 1983 interview, Gordon Firebaugh, a pilot for VF-2, told Buffalo historian Jim Maas that it was this model that suffered the most landing gear failures: Its weight, and the consequent increase in landing speed, caused the wheel strut to bend out of alignment. Mechanics filed off a bit of metal so the wheel could retract, and after a few such fixes it broke.

The Navy solved the F2A-3 problem the way it often solved problems with unsatisfactory equipment: by giving it to the Marines. By November 1941, the "First Team" of carrier fighter pilots was equipped almost exclusively with Grumman Wildcats.

On December 7, the Navy and the Marines had 47 Brewster fighters in the Pacific. The Dutch had around 70, and the British had more than 150. Against Japan, this wasn't the puny force it would have been in Europe. The Mitsubishi company was building just one of its "Type Zero" naval fighters per day—a rate that even Brewster Aeronautical could match. Less than 400 Zeros were in combat squadrons when the war began, and the Nakajima company had shipped just 50 of its equivalent Type One army fighter, popularly called Hayabusa (Falcon). Most land-based units were still equipped with the puny, fixed-gear Type 97 fighter. The Japanese fighters had a semi-bubble cockpit canopy, like the one Dayton Brown had given the Buffalo. And the Zero and Hayabusa were powered by the 14-cylinder Nakajima Sakae engine, a virtual clone of the Pratt & Whitney Twin Wasp. So they combined some strong points of the Buffalo and the Wildcat, while being nimble enough to fly rings around either.

"The pilot's cockpit is roomy and comfortable and well laid out," read an RAF report on the Brewster fighter.

In an advertisement published that December, Brewster boasted that its fighters were "carrier-based off Diamond Head," defending Hawaii. But no U.S. aircraft carrier was at Pearl Harbor when the Japanese arrived, so the U.S. Brewsters were spared the carnage of December 7.

In Malaya, where the date was December 8, the RAF sent unescorted Blenheim and Hudson bombers and even Vildebeests to attack the invasion fleet. The Buffaloes were used for strafing and reconnaissance—if they managed to get off the ground at all. Often their pilots were denied permission to scramble even when Japanese bombs were bursting on their airfields; those who did get into the air spent most of their time just trying to survive. Typical of the war's first days was an encounter on December 9 in which an Australian pilot aimed through an oil-smeared windshield and fired at his own wingman (fortunately, he missed).

Not until December 22 did the Commonwealth pilots meet the Japanese on nearly equal terms: 12 Buffaloes against 18 Hayabusas. The Japanese lost one, the Australians six. That settled the question of who owned the air over Malaya, and the RAF retreated to Singapore island.

Over Rangoon the following day, Vic Bargh saw his first *hinomaru*—the rising sun painted on Japanese warplanes. The American Flying Tigers got most of the credit for defending Burma, but RAF 67 Squadron was the vanguard that noon. It wasn't a happy experience: "We met 35 or 37 [fighters] and a big mob of bombers," Bargh recalls. "I had a fighter about two feet behind me all the time.... I had no armor plating, so I could see him easily. He was in a fixed undercarriage, what we called a Type 97 fighter. One [bullet] got by my ear. At that point I realized I couldn't turn with him any longer. I spiralled down and I came up again...and there was another mob of bombers." Bargh was credited with shooting down a twin-engine Mitsubishi bomber, meanwhile performing a stunt unique in the annals of aerial combat: He took off his boot, slid back the canopy, reached around, and cleaned the windshield with his sock. "The oil...would just get too hot and overflow," he explains. "As soon as the engine was at full throttle, this would happen.... But you had to use full throttle. The Japanese fighters were very good."

The New Zealanders survived that encounter, but on Christmas Day they met the same Hayabusas that had savaged the Australians over Malaya. Four pilots were killed and 13 Buffaloes destroyed.

"You had to be above them," Bargh explains. "And when you saw them coming, you pulled up steeply and rolled over on your back.... We were quite used to flying the aeroplane; it didn't matter a damn whether we were upside down or right way up. You just curled over at the top [and] twisted around so you came in from behind. Straight in behind. You can do it if you tipped upside down and you watched them coming along. I've done it, I've done it. I did it twice, and I lived."

Flight Sergeant Bargh was 21 years old that Christmas.

The Buffalo pilots claimed a few victories in 1942, but they left most of the fighting to the Flying Tigers and to Hurricane squadrons rushed in from North Africa. "They were a different lot to us," Bargh says of the Hurricane pilots, "and we were just left on the ground, gazing at them." Singapore fell in February and Indonesia in March. That was the end of the Buffalo in Southeast Asia.

Meanwhile, Brewster Aeronautical was going through another transformation. Jimmy Work and the Miranda brothers, free after five months in Lewisburg, got rid of George Chapline, the Navy's man, and installed a president more to their liking. Then the stockholders sued the company for

NASM (2)

$10 million, alleging various financial shenanigans.

That was it for the U.S. Navy. In April 1942 the government seized Brewster Aeronautical and put the former head of the Naval Aircraft Factory in charge. The ostensible reason was the criminal past of the Miranda brothers, but historian Jim Maas suspects that the Navy's Bureau of Aeronautics was punishing Brewster for chasing export business while the Navy cooled its heels, waiting for fighters. "BuAer got ticked," Maas speculates, "and they had long memories."

The Navy wanted no more Buffaloes. It had contracted with Brewster for a new dive bomber (SB2A Buccaneer) and had it manufacture the redoubtable gull-wing Corsair fighter (F4U when it came from Chance Vought, F3A from Brewster). One reason for America's astonishing output during World War II was the government's policy of contracting one company to build another's airplanes. The Wildcat, for example, was given to General Motors, while Grumman concentrated on its F6F Hellcat.

The British and Dutch flew Buffaloes in Southeast Asia and found them wanting, not least because the climate aggravated engine overheating. RAF pilot Vic Bargh managed to survive combat against the Japanese and posed with the wreckage of a Mitsubishi bomber he claimed over Rangoon (below).

COURTESY VIC BARGH

In the Pacific, the Navy had eliminated the Buffalo from its aircraft carriers. However, VMF-221 on Midway atoll still had 20 in service, plus six Wildcats. Like the colonial pilots in Malaya, Burma, and Indonesia, few of the Marines had ever seen combat, which probably had something to do with their fate in the Battle of Midway.

Their ordeal got under way at 6:12 a.m. on June 4, when Captain John Carey cried into his microphone: "Tally ho! Hawks at Angels Twelve!" VMF-221 dove on two squadrons of single-engine Nakajima bombers—the hawks at 12,000 feet—and the escorting Zeros fell upon the Marines. The Americans were stunned by the ferocity of the Japanese pilots and the maneuverability of their fighters. Charles Hughes, forced by a balky engine to return to Midway, saw two friends assailed by Zeros. One was shot down and the other was saved only by flak from the atoll's guns. "Both looked like they were tied to a string while the Zeros made passes at them," Hughes wrote in his combat report.

When the slaughter was done, six Buffaloes and four Wildcats returned to Midway. The Japanese had shot down 15 American fighters in the 45-minute brawl, for the loss of just two Zeros. In the end, though, the victorious Zero pilots had to swim for it. U.S. Navy dive bombers sank their carriers, a blow from which the Japanese navy never recovered. VMF-221 didn't fight again until the Guadalcanal campaign in August, and the Marines ever after knew the Buffalo as the "Fly-


B-3119

Model 339Ds intended for the Netherlands East Indies fly over New Jersey in May 1941. Per U.S. regulations, they wear civil markings, which were put on with tape.

While scorned elsewhere, the Buffalo was loved by the Finns. They used the airplane, adorned with the swastika-like hakaristi, *to post significant victories against Soviet pilots.*

ing Coffin," an airplane not merely disliked but passionately hated. As in Malaya, the Brewster was blamed for a disaster that might better have been attributed to faulty tactics, inexperienced pilots, and poor command decisions.

In truth, the Buffalo wasn't all bad, especially in its early incarnations. Gordon Firebaugh, promoted to lieutenant junior grade and flying a Grumman Wildcat, was shot down at Guadalcanal. "I've often thought that ...I'd [have] been better off in a Brewster," he told Jim Maas. "I think it would have matched the Zero. The [Wildcat] was heavier and didn't have the turning radius."

Meanwhile, the Brewster export fighters had become the mainstay of the Finnish air force. The Finns admired the Model 239, regarding it as simply constructed and easily repaired. (It helped that their state aircraft factory was close to the front, and their mechanics were inventive. Finding that oil didn't circulate freely through the engine, for example, they inverted a cylinder ring and solved a problem that plagued the Brewster wherever it served. It probably also helped that Finland was colder than Malaya or even Britain.) To bring the 239s up to snuff, they added armor plate and modern gun sights. "The more we played with it," recalled Joppe Karhunen in 1982, "the more we liked it."

The Finns called their Brewster *Taivaan Helmi* (Sky Pearl) and made a copy they called the *Humu* (Distant Storm). Their variant had wooden wing panels and a captured 1,000-horsepower Russian engine, a Cyclone lookalike that was also used to re-equip some 239s. For a recognition mark, the Finns used a blue *hakaristi*, a bent-leg cross that signified good luck in Nordic lands. Thus it happened that a warplane supplied by the United States came to carry an insignia resembling the Nazi swastika.

It also fought on the German side. In June 1941, with his troops occupying most of western Europe, Hitler turned east against his former ally, the Soviet Union. To Finland, this opened up the "continuation war" against the U.S.S.R. Its 239s were flown by Lentolaivue 24, combat-hardened men who were fighting to regain the land they'd lost in the Winter War. Before the war ended, Finnish pilots in 239s were credited with destroying 500 Russian aircraft at the cost of only 28 Brewsters.

Overclaiming? Oh yes. Most air forces overclaim, for a variety of good reasons. But the Finns certainly exacted a terrible vengeance for their losses in the Winter War, using the fighter that the British and Americans had condemned as a deathtrap.

To be sure, the combat wasn't entirely a case of the Finnish Davids fighting off the Soviet Goliath. Joseph Stalin had purged his officer corps in the 1930s, eliminating anyone who showed signs of independent thought. In the case of the Red Air Force, the result was formations that doggedly held their course while the enemy cut them to pieces, and pilots who stormed into combat without "checking six" (looking to the rear). Gunsights often consisted of a circle hand-painted on the windscreen, and the airplanes were obsolescent. This was especially true on the Finnish front, where a future ace named Hasse Wind claimed his first victory against a Polikarpov I-15 biplane.

In 1944 the Soviet Union forced another armistice upon the Finns, requiring them to turn against their former ally. So it happened that the Brewster's final victory was a Ju-87 Stuka, shot down on October 3, 1944.

COURTESY JIM MAAS

Postwar, Finland was allowed an air force of 60 airplanes. Among them were at least two Brewsters, used as advanced combat trainers until 1948. Even today, the *Humu* prototype remains on display at a museum in Tikkakoski, the only surviving specimen of the hapless Buffalo series.

As for Brewster Aeronautical, the company outlasted the war, though not by much. When the Navy canceled Brewster's last government contract, for the Corsair assembly, on July 1, 1945, the end was near. In October the company reported a net loss of $527,808, and its management decided that "the prospects for profitable future operations were not such as to warrant the corporation to continue in the airplane business." Or in any business. On April 5, 1946, the stockholders voted to dissolve the Brewster Aeronautical Corporation.

For more information about the Brewster Buffalo, browse the Web at www.airspacemag.com/supp/JJ96/supp5.html

>SIGHTINGS<

The U.S. Navy Flight Demonstration Squadron, better known as the Blue Angels, will hit middle age on June 15 when it turns 50, and like most baby boomers, its motto could be "We're not getting older, we're getting better."

Their original name, Lancers, lasted only a month before the current name was adopted (legend has it that it came from a Manhattan nightclub). The first team flew Grumman F6F Hellcats, then worked its way through four more Grumman varieties before switching to the McDonnell F-4 Phantom II in 1969. After the noisy, smoky, and much-loved Phantom, the Blues stayed with McDonnell Douglas craft through today's F/A-18 Hornet (you'll never hear a Blue Angel describe his airplane thusly; it's simply "my jet.")

Photographer George Hall caught the lead solo streaming condensation in a high-G, high-speed, high-humidity maneuver, and the diamond formation flat on its back, at the team's California site in El Centro during the 1995 practice season. Hall, who specializes in military aviation, has been photographing airplanes for 25 years.


U.S. NAVY
U.S. NAVY

Why They Launched

The Challenger Launch Decision: Risky Technology, Culture, and Deviance at NASA *by Diane Vaughan. University of Chicago Press, 1996. 590 pp., b&w photos and diagrams, $24.95 (hardcover).*

SCOTT ANDREWS

An accident waiting to happen? Challenger *just before the fatal flight.*

Unlike the typical shuttle launch, Diane Vaughan's book arrived right on time—the 10th anniversary of the *Challenger* tragedy. Vaughan, a sociologist, offers a new explanation for the disaster. For a book that must combine techno-speak with social science jargon, it's well written and deserves a look.

Common wisdom says the space shuttle was built on too tight a budget and that NASA promised a too-ambitious launch schedule. As a result, NASA and its contractor, Morton Thiokol, used a second-rate design—the infamous O-rings—and began to cut corners. Eventually they paid for their mistakes.

While this explanation has the familiar ring of a bureaucracy gone bad, Vaughan argues that the problem was more complicated. She demonstrates that NASA and its contractors were, if anything, extraordinarily careful. Indeed, that was one reason why the program had fallen so far behind.

Vaughan believes NASA workers and their contractors were caught in a web not of their own making. She analyzes the shuttle organization and dissects the critical teleconferences between NASA and Thiokol during the hours before the launch. The most significant problem, Vaughan concludes, is that the NASA-Thiokol organization was so segmented that no one had a total picture of the potential risks. So when NASA asked Thiokol whether it was risky to launch during cold weather, NASA officials only saw the decision reached by the company as a whole: Launching was okay. NASA managers could not know that within Thiokol several people had dire reservations.

Vaughan also looks at how an engineering organization progressively expanded the range of acceptable risk. NASA and Thiokol both knew that the O-rings had not sealed perfectly in earlier launches. But they also believed that they understood the problem and had it in hand.

Vaughan's explanation of *Challenger* is more detailed and interesting than what has passed before. But is it better? The fact remains that even the most reliable launch vehicles have a failure rate of one to two percent. Indeed, many experts agree that the risk of losing a shuttle—representing a half-dozen lives and about $3 billion in hardware—is still about one in 100.

The NASA and Thiokol engineers did their jobs and got a bum rap. No matter what they did, simple probability says that eventually a shuttle would be lost. The *Challenger* launch decision was made in Washington, D.C., not Utah or Florida. It's hard to explain why we risk so much on a cosmic roll of the dice. The wonder of it all is that we are still doing it.

—Bruce Berkowitz is a consultant in Alexandria, Virginia, who often writes on space policy.

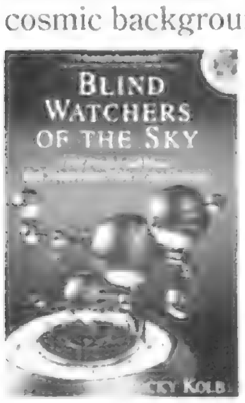
Kid Vid

The Big Aircraft Carrier. *Produced and directed by William VanDerKloot. Little Mammoth Media, 1995. 40 minutes, $14.95 (VHS).*

Children with an interest in airplanes should find *The Big Aircraft Carrier* pretty enthralling stuff. The video packs a great deal of information about carrier operations into its 40 minutes, without condescending to its audience. The footage, taken aboard the USS *Nimitz* (which weighs as much as 15,000 schoolbuses, in case you were curious), should prove interesting to adults as well. The video also includes a great credit: Creative Consultants were "Ms. Bennet's and Ms. Young's Kindergarten."

Blind Watchers of the Sky: The People and Ideas that Shaped Our View of the Universe *by Rocky Kolb. Addison-Wesley, 1996. 330 pp., b&w photos, $25.00 (hardcover).*

Rocky Kolb, one of America's leading cosmologists and particle physicists, has written an engaging description of the progress of astronomy from the 16th century through the discovery of the cosmic background radiation in 1964.



Kolb devotes the first half of his book to the astronomical revolution ignited by Copernicus, Tycho Brahe, Kepler, Galileo, and Newton; he then turns to the still-vexing question of how to estimate the distances to astronomical objects, guiding the reader through the debates over the nature of the nebulae to reach Edwin Hubble's triumph in demonstrating the extragalactic nature of the Andromeda galaxy. The book's final chapters deal with the Big Bang, the "primordial soup" of elements that emerged from that crucial moment, and the radiation produced by the early universe.

Throughout *Blind Watchers of the Sky*, Kolb reveals a deft touch in both explanation and anecdote. Though the tale of astronomy from Copernicus to Newton has often been told, I think that Kolb's summary ranks with the best, and I would place his pages ahead of those in Arthur Koestler's *The Sleepwalkers* or Timothy Ferris' *Coming of Age in the Milky Way*. Kolb nicely weaves together the key advances and personal lives of the astronomers he describes and includes many fine asides, such as a footnote pointing out that in past centuries, astronomy thrived best under mentally disturbed rulers: Denmark's King Frederick II supported Tycho's observational megalomania; Britain's King George III served as the patron of William Herschel. Kolb's description of the "Great Debate" over the nature of spiral nebulae, held in April 1920 in Washington, D.C., includes an insightful and witty running commentary that underscores the fact that Harlow Shapley, who asserted that spiral nebulae observed by astronomers were not galaxies like our Milky Way, won the debate—and was dead wrong. When he turns to the discovery of the cosmic background radiation, Kolb says more in a few pages than other authors have in twice the space; especially valuable is his emphasis on the statement that "the most difficult thing to discover is something for which you are not searching."

My only quibble with Kolb's presentation is his misspelling of a few names and his misplaced admiration for Edwin Hubble as a person. Relying on Gale Christianson's recent biography (reviewed in the Dec. 95/Jan. 96 issue), I would argue that Hubble offers a perfect example of the widely observed rule that great scientists can have enormous flaws as human beings.

My much greater regret about this book is that I miss what Kolb could have written about the stunning cosmological advances and controversies of the past three decades, which astronomers of the next century may regard as pivotal in our understanding of the cosmos. Since Rocky Kolb works at the center of this effort, I hope that he will make it the focus of his next book, which I eagerly await.

—Donald Goldsmith is an astronomy writer in Berkeley, California. His most recent book, Einstein's Greatest Blunder? The Cosmological Constant and Other Fudge Factors in the Physics of the Universe, *was published last year by Harvard University Press.*

First in Flight: The Wright Brothers in North Carolina *by Stephen Kirk. John F. Blair, 1995. 341 pp., b&w photos, $16.95 (paperback).*

If you've ever spotted those stylish North Carolina license plates, you won't have to guess what this book is about. But for the record, author and North Carolinian Stephen Kirk has scoured every local newspaper, magazine, and archive for anecdotes and evidence concerning the Wright brothers' various visits to the Tar Heel State. Then again, it's not so much about the Wrights in North Carolina as it is about the cast of normally ancillary characters there who stumbled upon them and thus into the pages of history. I'm talking about folks like Bill Tate, who took the brothers into his home when they were just strangers, Yankees, and cranks, and John Daniels, who snapped the famous photograph of the first flight. It turns out that these and many others actually had lives before and after they crossed paths with the Wrights.

This detailed, painstakingly researched volume is a fun mix of fascinating minutiae and regional boosterism. It reminds me of the famous *New Yorker* magazine cover in which the foreground, Manhattan, is spread out in lavish detail while America and then the world appear on a much-diminished scale.

Only in this instance the foreground is a huge Kitty Hawk, followed by a slightly smaller North Carolina, then a microscopic Ohio. When Dayton's Charlie Furnas shows up at the Wright camp, for example, he is portrayed initially as a white knight, but Kirk regretfully notes that Furnas went on to became the first passenger in an airplane, depriving an area native of the honor. Of course, it's not like the world, or even Dayton, actually celebrates a Charlie Furnas Day. But maybe there'd be the equivalent in Kitty Hawk if events had turned out differently.

If that brand of local focus is a flaw, it's not a major one. For even the most jaded Wright aficionado, this book is a must.

—Phil Scott is the author of The Shoulders of Giants: A History of Human Flight to 1919 *(Addison-Wesley, 1995).*

Classic RAF Battles from World War One to the Present, *edited by Michael Armitage. Arms and Armour Press, London, 1995 (distributed in the U.S. by Sterling Publishing, 387 Park Ave. South, New York, NY 10016). 171 pp., 40 color paintings, $29.95 (hardcover).*

Forty superb color paintings by 16 British aviation artists celebrate the solid old Royal Air Force. The well-informed and thoughtful essays by 14 authors not only add understanding to the painters' gripping snapshots of blazing action, but, like a 39-episode Masterpiece Theatre story, outline the RAF's 82-year history.

The service started in 1914 as the Royal Flying Corps; at war's outbreak it deployed to France with 63 primitive aircraft. The book's first account of the Corps in action depicts one of its Morane-Saulniers, flown by a young Royal Naval Air Service sub-lieutenant, wheeling

around an evening sky as a giant German zeppelin drops blazing to earth.

The next painting captures Germany's great Werner Voss in his final combat, flashing past a Royal Flying Corps S.E.5 at unbelievably close range. Badly outnumbered, Voss had no chance, but he won the admiration of the Brits for his stubborn fight in a Fokker triplane. "He whipped around…using no bank at all," reported a British adversary. That rang a bell: Watching a demonstration of World War I aircraft, I marveled at a triplane's turns, flat as a Frisbee.

The World War II sections churned up more memories. I trained with RAF cadets in Selma, Alabama, made friends with them, and struggled to meet the demands of an RAF gunnery instructor. I recall with some amusement the RAF types of those days.

Intensely professional: If the task looks impossibly hairy, just shut up and do it. Deeply motivated: "I just want to get through this bloody course and start killing the bastards." Occasionally a bit…well, feckless. "I say, is there something wrong with the motor if it goes 'wonka-wonka-wonka?' "

Perhaps that nurtured naiveté resulted from the between-wars years, when the RAF, having paid its dues in World War I, became the world's best flying club. The book marks that struts-and-wire era with a portrait of Westland Wapitis flying over Kurdistan. In fact, biplanes flew into World War II, depicted in a painting of Gloster Gladiators fighting Italian Savoia Marchetti bombers over Malta. Peter Cooksley writes of the four Sea Gladiators the RAF had at Malta. Usually only three were flyable, known as Faith, Hope, and Charity—or Pip, Squeak, and Wilfred, cartoon characters from the *Daily Mirror*.

World War II gets spectacular coverage, with text so logically organized that the military strategy falls neatly into place. Post-war jets and helicopters, deployed everywhere from Northern Ireland to the Gulf war, get the same treatment: grand spectacle beefed up with well-told accounts. I had forgotten that the United Kingdom carried on a 12-year "action" in Malaya until I read editor Armitage's clear account.

—Edwards Park is a frequent contributor to Air & Space/Smithsonian *and the author of* Nanette, *an account of his experiences in a P-39 during World War II.*

CREDITS

Heart Breaker. A rendezvous and proximity operations instructor at NASA's Johnson Space Center, Robert J. Mahoney has been working on tethered-satellite shuttle missions for seven years. He reports that this year his wife Margie filed her tax return under the status of tether widow. The opinions expressed in his article are not necessarily those of NASA or its aerospace contractors.

Gossamer Wings. William E. Burrows is not writing a biography of Sergei Korolev entitled *Naked Came the Chief Designer.*

The Big Sweep. Prior to exiting a submerged helo simulator upside down and blindfolded for this article, San Francisco-based writer Michael Alves and Oakland, California photographer Sam Sargent last teamed up for a book about bulldozers. Sargent, who has several other books and hundreds of aircraft shots to his credit, likes to photograph big objects outdoors. And after the hardware stores close, Alves enjoys writing about things with wings.

Dog Is My Copilot. Allan Janus is the exhibit coordinator for the National Air and Space Museum's archives division. The Fauna Files, a selection of the archives' animal images (including some from "Dog Is My Copilot"), will be on display in the Museum through January 1997.

The Loneliness of the Long-Duration Astronaut. Henry S.F. Cooper Jr. is the author of eight books about the space program, including *A House in Space* (Holt, Rinehart, Winston, 1976), which described the Skylab program.

In the Grip of the Whirlwind. Carl A. Posey, who lives in Alexandria, Virginia, is the author of *Wind and Weather* (Reader's Digest, 1994). He wrote "Ozone Forecast: Partly Cloudy" for the Oct./Nov. 1994 issue.

A resident of Carroll County, Maryland, John Kachik has been painting scenes of Baltimore for over 10 years. To his delight, he was cast as an extra in the 1982 movie *Diner*, which was filmed in Baltimore.

Pluto's Portrait. Tony Reichhardt, a frequent *Air & Space* contributor, lives in Fredericksburg, Virginia.

The Contrabandistas. Frequent contributor Homer H. Hickam Jr. was a friend of pilot Harold "Swede" Larson. He reports that Larson is "sorely missed by

CREDITS

all who were lucky enough to know him."

Steve McCracken is a Washington, D.C.-based illustrator. His last work for *Air & Space* appeared in "The Flight Attendants" (Apr./May 1993).

The Sorry Saga of the Brewster Buffalo. Contributing editor Daniel Ford wrote "B-36: Bomber at the Crossroads," which appeared in the last issue. He has posted a Buffalo page on the World Wide Web at http://concentric.net/~danford/buff.html. Jim Maas, Panu Kolju, and Ben Schapiro contributed to this article.

Further reading: *F2A Buffalo In Action*, Jim Maas, Squadron/Signal, 1987.

Temple of the Holy Spirit. Frequent Collections contributor Richard Sassaman, who wrote the first *Air & Space* story about the Lindbergh Crate, continues to follow the project.

CALENDAR

June 1 & 2
T.C. Thompson Children's Hospital Airshow. Chattanooga Metropolitan Airport, TN, (423) 778-KIDS.

June 8 & 9
Air Capital Air Show. Col. James Jabara Airport, Wichita, KS, (316) 683-9242.

Confederate Air Force Ranger Wing Fly-In. Waco, TX, (817) 756-2135.

"My Waterloo Days" Airshow. Waterloo, IA, (319) 234-7745.

Ville de La Baie International Airshow. BFC Bagotville, Ville de La Baie, Quebec, Canada.

June 9
Pottstown Aircraft Owners & Pilots Fly-In. Pottstown-Limerick Airport, PA, (610) 277-7022.

June 14–16
Hamilton International Air Show. Hamilton Airport, Ontario, Canada, (905) 528-4425.

June 15
EAA Antique Classic Chapter 7 Fly-In. Aeroflex-Andover Airport, Andover, NJ, (201) 786-5682.

June 16
Father's Day Air Affair. Salmon Arm, British Columbia, Canada, (604) 832-1000.

June 21 & 22
Callair Fly-In and Star Valley Aviation Days. Afton Municipal Airport, Afton, WY, (307) 886-9881.

June 21–23
World War I Fly-In. Gardner, KS, (913) 788-5435.

June 22 & 23
EAA Chapter 36 Fly-In. Potomac Airpark, Berkeley Springs, WV, (717) 294-3221.

June 26–29
Sentimental Journey to Cub Haven Fly-In. William T. Piper Memorial Airport, Lock Haven, PA, (717) 893-4207.

June 27–30
PB4Y All Squadron Reunion. San Diego, CA, (510) 487-PB4Y.

July 4
Rockport-Fulton July 4th Airshow. Aransas County Airport, TX, (800) 242-0071.

July 12–14
Great Texas Ballon Race. Gregg County Airport, Longview, TX, (903) 237-4000.

July 13
Aviation Space Fair. Oklahoma Air Space Museum, Oklahoma City, OK, (405) 424-0203.

Golden Empire Flying Association Fly-In. Nevada County Airpark, Grass Valley, CA, (916) 274-1040.

July 13 & 14
7th Annual Helicopter Round-Up. Randall Airport, Middletown, NY, (914) 344-8626.

July 20
Lion's Club Fly-In Fish Boil. Washington Island, WI, (414) 847-2770.

July 20 & 21
"Dawn Patrol Rendezvous": U.S. Air Force Museum, Dayton, OH, (513) 255-4704.

July 26–28
Norseman Float Plane Festival. Red Lake, Ontario, Canada, (807) 727-2809.

"The Satellite Sky" Update/54

These regular updates to "The Satellite Sky" chart will enable readers to keep their charts up to date. Additions can be clipped and affixed to the chart at the appropriate altitude.

New launches

90 to 300 MILES

- Soyuz TM-23 2-21-96 TT
- Cosmos 2331 3-14-96 PL

300 to 630 MILES

- Rex II 3-9-96 L-1011
- IRS-P3 3-21-96 ISRO

630 to 1,250 MILES

- Gonets 1-3 2-19-96 PL
- Cosmos 2328-30 2-19-96 PL

6,200 to 13,700 MILES

- Raduga 2-19-96 TT
- GPS-25 3-28-96 CAC

21,750 to 22,370 MILES

- Palapa C-1 2-1-96 CAC
- N Star-b 2-5-96 KOU
- Intelsat 707 3-14-96 KOU
- Echostar 1 12-28-95 XI

Inoperative but still in orbit

300 to 600 MILES

Cosmos 2266
Cosmos 2321
NOAA 11
Skipper

6,200 to 13,700 MILES

Navstar 10

21,750 to 22,370 MILES

Telecom 1C
Kopernikus-1
Raduga 31

Deletions

90 to 300 MILES

Space Flyer Un
down 1-20-96

Progress M-30
down 2-22-96

Soyuz TM-22
down 2-29-96

Launched but not in orbit

90 to 300 MILES

STS-76 U.S. research	3-22-96	down 3-31-96

DATA: SAUNDERS KRAMER

FORECAST

In the Wings...

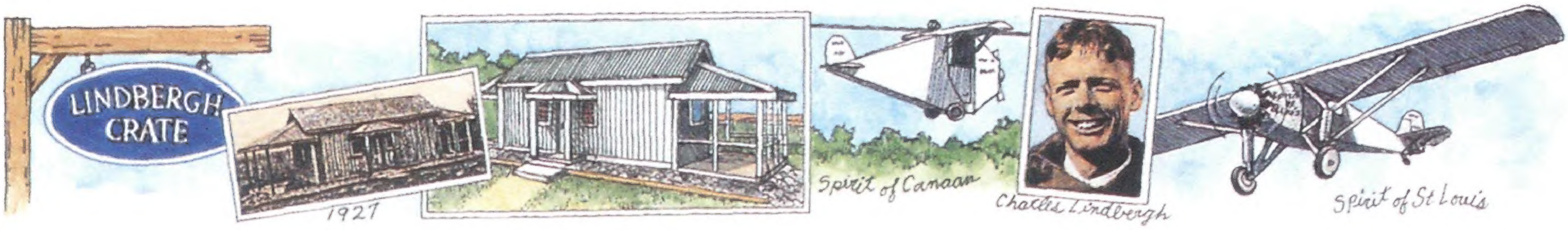
Helicops. When the Los Angeles community of Watts rioted in the summer of 1965, the L.A. police department brought out its helicopters. They've been fixtures of urban police work ever since. But how can we tell if they're really effective?

Engine Transplants. An aircraft engine can be a tad expensive. So why not just slap an old Chevy V-8 into an airframe and save some money? Of course, it's not that simple, but engines now being tested may make the move from turning wheels to turning propellers.

The Deal Makers. What do frozen pizzas, grain elevators, and cellular telephones have to do with a foreign government's decision to purchase U.S. fighters? The operative term is "offset." Behind every sale is a team dedicated to making sure the customer gets a piece of the action.

Skyhook. In the early 1960s the Navy tested an invention that would retrieve downed airmen and reel them into an airplane. The last few feet were the hardest.

New Millennium. NASA says its newest spacecraft will be technology pathfinders. Critics charge that the laboratories that worked on Star Wars defense systems have already been down that path.



JOHN HEINLY

Temple of the Holy Spirit

In Canaan, Maine, you will find one of the most charming aviation museums in the United States. But you will not find a single real airplane on display.

The museum's biggest artifact is itself: the Lindbergh Crate. The Crate is a 29-foot-long pine box that once played a modest supporting role in aviation history. It was in this box that Charles Lindbergh, just weeks after making his 1927 solo crossing of the Atlantic, packed the *Spirit of St. Louis* for return to America.

When the aviator and his airplane disembarked from the journey home aboard the USS *Memphis*, Vice Admiral Guy Burrage, commander of the Navy's European fleet, asked if he could have the Crate as a souvenir. Burrage turned it into a summer cottage on his land in New Hampshire.

Though at one time the cottage was equipped with electricity and a telephone, over the years it slowly deteriorated. Then Larry Ross came along. In 1990 he read in a newspaper that the Crate was for sale. Blessed with an understanding wife, he paid $3,000 for the honor of going into the New Hampshire woods with a friend and hauling the Crate north to his back yard [see " 'There Will Always Be a (New) England' Dept.," Soundings, June/July 1990].

"Burrage's grandchildren called it 'the Shack,' " Ross says. "It was kind of a bunkhouse in back at their place." He has nicely restored the Crate to its cottage appearance, helped by the "Schemers and Dreamers," three dozen friends and local businesses who donated construction materials and assisted with the work.

So has Ross always had a thing for the Lone Eagle? "My dad was a pilot and I always liked airplanes, but no, not really," Ross admits. "We always used to travel; my parents indulged my love of history, and I particularly remember Mt. Vernon, and Abraham Lincoln's house. Walking where Lincoln himself had walked. As for the Crate—I guess I wanted something that had been a part of history, and this was just the right thing at the right time."

He adds: "When I bought the Crate, I knew I wanted to restore it. And then immediately I started meeting people who shared their memories and I got more interested. What was the true 'spirit' in the *Spirit of St. Louis*? I'd see a man standing next to Lindbergh in an old photograph and wonder: *Who is that? Is he still alive?* I made a lot of phone calls and wrote hundreds of letters, following the connections as one person led to another.

"I don't really want Lindbergh collectibles, the stuff people trade among themselves," Ross says. "I've already bought the biggest collectible. All I want to know is 'What did your grandmother say about Lindbergh?' "

The Lindbergh Crate, RFD 2, Box 5130, Canaan, ME 04924. Phone (207) 474-9841. To arrange a visit or contribute memories, please contact the museum. Free admission.

Visitors to the Crate can page through scrapbooks filled with personal accounts Ross has received. There are letters from well-known people—Jimmy Doolittle, Jimmy Carter, various astronauts—and dozens of ordinary folks as well, such as Francis Bixby Caldwell, whose father Harold named the *Spirit of St. Louis*, and Glenn Messer, who in 1923 gave Lindbergh space for his first Curtiss Jenny in a Georgia hangar, as well as a few flying lessons. Not long before his death, Alabama enthusiast Charles White McGehee sent Ross a small crate of his own: Packed with aviation history from the 1920s, the box included scrapbooks McGehee had compiled about Lindbergh, Amelia Earhart, and McGehee's personal hero, Admiral Richard Byrd.

Ross has also heard from a woman who for six years actually lived in the Crate back in New Hampshire. In 1977, three days after the 50th anniversary of Lindbergh's Atlantic crossing, Deanna Stiles gave birth in the Crate to a daughter, Amelia. Ross has a tape of Stiles' Hotcakes Band (with her on flute) playing a country dance tune entitled "Lindbergh's Crate."

Visitors to the Crate have included Lindbergh's daughter Reeve (she left her business card because Ross wasn't home), Admiral Burrage's grandson Bill, and Vince McGovern, who in July 1952 served as a pilot on the first helicopter flight across the Atlantic.

Some people have been bewildered by all the fuss. When Ross first wrote to Apollo 13 commander Jim Lovell, the astronaut wrote back: "I admire your devotion. However, I fail to see the reason for all this effort.... The crate contributed nothing to Lindbergh's success." Ross eventually convinced Lovell that his interest in the Lone Eagle was serious, and Lovell sent an autographed photo. So did Alan Shepard, who wrote on his: "With thanks for honoring my hero!"

The Lindbergh Crate is a simple place, where a tape plays scratchy old songs about "Lucky Lindy" and donations are accepted in a Chase & Sandborn coffee can by the door. Except during anniversary celebrations, your group will most likely be the only visitors that day.

Homey as it is, the Crate now boasts not one but two mini-airplanes. A Massachusetts man named Bernard Taylor contributed a beautiful 1/16-scale model of the *Spirit of St. Louis*. Taylor also helped persuade Ross to construct another dream: the *Spirit of Canaan*, a 13-foot-long plywood model of Lindbergh's airplane. With installation expertise donated by a Central Maine Power lineman, it's been rigged to a cable that stretches between a telephone pole and a tree 170 feet away. You climb into the model and your host uses a long rope to pull you and the airplane to the top of the telephone pole. Then he lets go and the plywood *Spirit* "flies" along the cable through the Maine countryside. "I'm going to get a Statue of Liberty at one end of the ride," Ross says, "and an Eiffel Tower at the other."

—*Richard Sassaman*